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**Superphosphate Requirements for Growing Wheat in
Western Australia.**

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A.—SUMMARY.

1. Since the establishment of the research stations, commencing with the Chapman Experimental Farm in 1902, experiments have been conducted to determine the most satisfactory rate of application of superphosphate for wheat growing. These stations cover a wide range of soil and climatic conditions which are briefly described in the text, and are representative of the wheat belt of Western Australia. The main series of experiments discussed were commenced in 1929, and are being continued at the present time.

A number of experiments have been carried out on private farms with similar results.

2. A wide range of superphosphate applications has been used in these experiments, and from the data provided the most payable dressings for wheat growing under wheat belt conditions can be determined after allowing for the cost of superphosphate and the price of wheat. The probable yields under other rates can be predicted from an examination of the yield data illustrated in curves presented in the paper.

3. From the results of the 1929 series the most payable applications of superphosphate (22% P_2O_5) on the Research Stations appear to be:—

Chapman	..	..	..	80 lbs. per acre.
Dampawah	..	..	..	100 lbs. per acre.
Wongan Hills	..	..	..	130 lbs. per acre.
Merredin	..	..	..	110 lbs. per acre.
Yilgarn	..	..	..	130 lbs. per acre.
Salmon Gums	..	..	..	110 lbs. per acre.

These rates closely approximate those adopted on the research stations for bulk crops.

Experiments commenced in 1941 show these applications are now generous, as considerable improvement in the phosphate status of the soil has resulted from the superphosphate applications under the cropping programme since 1929. These new experiments show that the rate of superphosphate applications on old well-fertilised land may be reduced below the figures suggested above without reduction in monetary return.

4. The wheat crop in Western Australia on the average absorbs less than one-third of the phosphate in the normal superphosphate applications used in wheat growing. The residue of the phosphate is not washed out by the rains, but is held in the soil in a condition in which it is slowly available to the wheat crop and succeeding pasture crops. As the amount of superphosphate applied is increased the residues in the soil increase and the availability of these residues improves.

5. The effect of the residues of only a few hundredweights of superphosphate applied in the previous cropping programme is very marked.

On normal soils it is desirable to apply superphosphate as generously as possible with the early crops to build up phosphate reserves quickly. If necessary, economy can then be practised with little loss.

6. On plots sown without superphosphate, the growth and maturity of the wheat has been delayed, but yields of grain reported in this paper have been surprisingly good.

7. The application of superphosphate at the seeding time, even of very small amounts when adequate supplies are not available, is advised. The early growth is improved and the maturity hastened. This may be very important in unfavourable seasons.

8. To make best use of the superphosphate ration available for wheat growing, farmers are advised to spread it over the area for which it is allocated, in order to obtain the maximum benefit from the early growth stimulation and earlier maturity. Only the most satisfactory land, which has been well prepared and has been well fertilised with superphosphate in the past, should be cropped, under the acreage restrictions, to get utmost advantage from the superphosphate residues in the soil.

It is recognised that generous use of superphosphate can never compensate for unsatisfactory farming methods or adverse seasonal conditions.

B.—INTRODUCTION.

In their natural state the soils of Western Australia are notoriously deficient in available phosphate and the use of phosphatic fertilisers, chiefly high-grade superphosphate, is standard practice on practically all farms and for most crops.

With respect to the wheatbelt, the need for available phosphate is as general as elsewhere. The seeding machinery is all equipped for the application of superphosphate with the seed. Farmers generally consider seeding and fertilising as a single indivisible operation.

So spectacular have been the responses to superphosphate on many types of new land, that is, land which has not previously carried a crop, that reduction in the supply of superphosphate occasioned by the war has caused grave concern. Many farmers believe that the result will be a disastrous reduction in the yield of wheat, even on old, well-fertilised land.

Fortunately, these fears are groundless as far as old, well-fertilised land is concerned because the residual value of superphosphate applications is high. It is realised that reduction of superphosphate applications below those normally used, 90-100 lbs. per acre may cause reduced yield of wheat, but the reduction will not be large, at least for a number of crops, and a crop failure, due to lack of superphosphate, need not be feared.

It is very fortunate that the effect of various rates of superphosphate on the yield of wheat has been studied over a considerable period of years on the agricul-

tural research stations in the wheatbelt. These cover a representative range of soils and climatic conditions. Briefly these may be summarised as follows:—

Chapman Research Station (Established 1902).

The Chapman Research Station lies in the northern part of the wheatbelt in the Upper Chapman Valley and is about 28 miles north-east of Geraldton. The soils are of the red-brown earth group and are representative of the lighter soils of the jam (*Acacia acuminata*), and York gum (*Eucalyptus foecunda* var. *loxophleba*) belt of the State. However, the range of soils includes loam associated with York Gum and flooded gum (*E. rudis*), loamy sand associated with jam and wattle (*Acacia* spp.) vegetation, and sandy and gravelly soils of the heaths.

The rainfall (1906-1942), averaged 18.25 inches of which 15.55 inches fell in the May to October, or growing, period. The seasonal rainfall is somewhat variable. The country represented by this station lends itself to mixed farming, with the emphasis on livestock and pasture improvement, rather than wheat growing.

Dampawah Research Station (Established 1926: closed 1940).

The Dampawah Research Station lies on the fringe of the "mulga"* belt. This country has not been regarded as agricultural, but is devoted almost entirely to sheep raising for wool production. The research station was established to test the capabilities for wheat growing and was located some 30 miles east of Perenjori, where eucalypts, chiefly sand York gum (*Eucalyptus Lucasi*) and giant mallee (*Eucalyptus oleosa*) and belts of cypress pine (*Callitris glauca*) alternate with mulga.

The soils are chiefly red sands and sandy loams related to the mulga types and a siliceous hard-pan is commonly encountered within 18 inches or two feet of the surface. In spite of the low rainfall, the soils are commonly acidic in reaction and lime accumulation, common in the low rainfall wheatbelt country, is not general.

The rainfall is light and variable. The average, 1929-39, was 11.85 inches of which 7.84 inches fell in the May-October, or growing period.

Wongan Hills Research Station (Established 1923).

Wongan Hills lies in the north central portion of the wheatbelt and is about 120 miles north-east of Perth. It is located on a stretch of rolling, heath country. The soils are sandy and gravelly in nature and granite occurs at shallow depths in parts. A gravelly clay subsoil is common over much of the area.

The rainfall, 1926-1942, averaged 14.29 inches of which 10.60 inches fell in the May-October, or growing period.

This locality is representative of a huge area of light land occurring throughout the wheatbelt of Western Australia and farming operations on the station have been very successful. It does not include the poorest types popularly known as "wodjil."

Merredin Research Station (Established 1904).

The Merredin Research Station is representative of the heavy brown and red brown solonised soils of the central wheatbelt. It lies in a broad valley running between Merredin and Nangeenan on the Eastern Goldfields railway line. In the virgin state the vegetation consisted chiefly of gimlet (*Eucalyptus salubris*) and salmon gum (*E. salmonophloia*) with a sprinkling of mallee, including *Eucalyptus gracilis*. On the northern and southern boundaries, areas of light land occur, but these have not been used to any extent for farming purposes.

*"Mulga" includes a variety of *Acacia* scrubs of the low rainfall areas of the State.

The soils consist generally of red brown loams and clay loams with a calcareous, sandy clay subsoil, typical of salmon gum and gimlet woodlands of the wheatbelt. Small patches of brown morrel (*Eucalyptus longicornis*) soils occur.

The rainfall, 1912-42, averaged 11.93 inches of which 8.07 inches fell in the May-October, or growing, period.

The soils are of good quality and highly productive when the rainfall is favourable. The station has a high reputation for wheat and sheep raising.

Yilgarn Research Station (Established 1926, closed 1940).

The Yilgarn Research Station lies about eight miles east of Southern Cross and, at the time of establishment in 1926, was on the outer fringe of the wheatbelt. This area is now regarded as sub-marginal for wheatgrowing and the station was closed in 1940.

The station embraces a wide range of country including heavy salmon gum woodland, giant mallee (*Eucalyptus oleosa* var. *transcontinentalis*) formations, snuffy morrel and sandplain, or heath, soils. The experiments with which this paper are concerned were located on medium soils of salmon gum and mallee vegetation associations. They ranged from brown sands to sandy loams with calcareous sandy clay subsoils.

The rainfall, 1928-39, averaged 10.52 inches of which 6.57 inches fell in the May-October, or growing, period.

Salmon Gums Research Station (Established 1926).

The Salmon Gums Research Station lies in a belt of mallee country in the outlying, south-eastern portion of the wheatbelt. The range of soils includes grey calcareous types, popularly known as "kopi," heavy clay soils, and sandy surface soils with a calcareous sandy clay subsoil. The rate of superphosphate experiment has been located on the sandy surface soils which are the most reliable of the district for wheat growing.

The rainfall, 1926-1942, averaged 13.62 inches of which 7.86 inches fell in the May-October, or growing, period.

The rainfall of the district is generally regarded as somewhat unreliable—much of it falls in the form of light showers and the spread is greater than in most other parts of the wheatbelt.

The district is considered to be suitable for stock raising with wheat growing only on the more satisfactory soil types.

C. PHOSPHATE ABSORPTION BY THE WHEAT CROP.

While the fertiliser requirement of a crop are not simply related to the amount actually absorbed by the crop from the soil, owing to the complex interactions between the soil and the fertiliser, it is of interest to consider the amounts taken up by the wheat crop under Western Australian conditions.

Western Australian wheats (grain and straw) are significantly lower in phosphate than the published standards for overseas crops. Snook (1939) shows that Western Australian wheat grain averages 0.55 per cent. P_2O_5 , a figure much lower than European and American standards which are of the order of magnitude of 0.85 per cent. P_2O_5 . The straw, too, is exceedingly low in phosphate. Underwood (private communication) has found Western Australian straw to average about 0.08 per cent. P_2O_5 . This is exceedingly low in comparison with English analyses of about 0.4 per cent. P_2O_5 .

The reason for this low phosphate content of Western Australia wheats is probably related to the low content of readily available phosphate in our soils. The superphosphate application in the rows with the seed gives a large supply of quickly available phosphate in the early growth stages when it is absorbed very rapidly by the young plant. As the season advances the soil renders the water soluble fraction relatively insoluble and slowly available so that the plant is only able to obtain further supplies at a greatly reduced rate. On this account the phosphate absorbed in the early growth stage has to meet the main requirements of the plant and under these conditions it is known that the phosphate content may be very low although the amount of growth is not impaired. Apparently the phosphate absorbed early is used most efficiently in plant metabolism,* but the grazing animal may be denied normal phosphate supplies.

Owing to the low phosphate content of our wheats the drain on the soils is less than would be judged by the usual standards. A 20-bushel crop would contain 5.9 lbs. of phosphoric acid (P_2O_5) in the grain and from 1.3 to 1.9 lbs. in the straw, depending on the grain: straw ratio. Thus, there would be a total of 7.2 to 7.8 lbs. of P_2O_5 in the above-ground portions of a 20-bushel crop. This is equal to 33-35 lbs. of 22 per cent. superphosphate or 40-43 lbs. of 18 per cent. superphosphate now available† (see footnote).

D. SUPERPHOSPHATE REQUIREMENTS.

The main questions with respect to superphosphate applications for wheat crops in Western Australia are:—

1. What is the most economical dressing of superphosphate to apply?
2. What is the residual value of superphosphate not actually absorbed by the crop?
3. What will be the effect of reducing the rate of application of superphosphate on the yield of wheat?

1. What is the most economical dressing of superphosphate to apply?

The most economical dressing of superphosphate will depend on the soil type, the climate, the seasonal conditions, the yield of the crop, the price of wheat, the price and grade of superphosphate, and the quantity of superphosphate previously applied.

Soil type, climate and seasonal conditions are covered by conducting experiments over a number of years on a number of representative farms.

As the prices of the commodities are not fixed the effect of these factors can only be stated in principle.

- (a) As the price of wheat increases the optimal‡ application of superphosphate increases.
- (b) As the price of the fertiliser increases the optimal application decreases.

The converse will also be true.

Experiments with varying rates of superphosphate on the wheat crop have been carried out on the Research Stations for many years. The main series was started in 1929, but prior to that experiments had been conducted over a number

*Metabolism is a general term referring to the chemical changes which take place during growth and maturation of the plant.

†It is of interest that the phosphorus in a 70-lbs. fat lamb (live weight) is equivalent to 3.6 lbs. of 22 per cent superphosphate; in a 10 cwt. fat bullock to 92 lbs.; and in 1,000 gallons of milk to 97 lbs.

‡The optimal dressing is defined as that which gives the greatest profit per acre. See figures 1 and 2.

of years on the Chapman, Merredin, and Wongan Hills Research Stations. During this period the grade of superphosphate used has varied as follows:—

Period.	Phosphoric Acid (Percentage P_2O_5)	
	Water Soluble.	Total.
1910-1915	17.0	20.0
1915-1916	17.0	17.0
1916-1923	17.0	18.0
1923-1937	20.5	22.0
1937-1941	21.25	23.0
1941-1942	20.25	22.0
1st November, 1942	14.0	18.0

The average price has been £4 12s. 6d. per ton, cash at works.

RESULTS OF THE EXPERIMENTS.

(a) *The Early Experiments.*

The earliest records available show that various experiments to determine the most economical rates of fertiliser application have been conducted since the establishment of the stations. Unfortunately much of these data has been lost, but the results of a number of experiments are of value. In general, these support the findings of the present experiments.

The results of the experiments prior to 1929 are summarised in Table 1. In addition to figures for the research stations, data from the Narrogin School of Agriculture for 1905-1906 are included for sake of interest.

TABLE 1.

RESULTS OF RATE OF SUPERPHOSPHATE EXPERIMENTS WITH WHEAT CARRIED OUT ON AGRICULTURAL RESEARCH STATIONS PRIOR TO 1929. RESULTS EXPRESSED AS BUSHELS PER ACRE AND AS PERCENTAGE OF THE CONTROL.

Research Station.	Period.	No. of Crops.	Estimated Prior Applications of Superphosphate.	Rate of Superphosphate per Acre.					
				Nil.		56 lbs.		112 lbs. (Control)	
			lbs. per acre.	bus. per acre.	%	bus. per acre.	%	bus. per acre.	%
Narrogin School of Agriculture	1905-1906	2	Unknown (possibly 112)	8.0	66	8.9	73	12.2	100
Chapman	1915-1917	3	700	11.2	92	11.8	97	12.2	100
Merredin	1915-1917	3	320	14.6	76	18.0	94	19.2	100
				75 lbs.		150 lbs. (Control)		225 lbs.	
Chapman	1923-1928	6	Paddock— 6A-540 19-720 21-320	15.9	91	17.5	100	18.5	106
Merredin	1923-1928	6	Paddock— 3-580 5-710 8-570	24.0	91	26.4	100	27.7	105
Wongan Hills...	1925-1928	4	None ...	13.0	71	18.2	100	19.2	105

The results of a number of experiments on private farms are given in Table 2.

TABLE 2.

RATE OF SUPERPHOSPHATE EXPERIMENTS ON FARMERS' PROPERTIES.

Average of two Plots.

Year.	Place.	Rainfall.		Rate of Superphosphate per acre.					
		Growing Period.	Total.	75 lbs.		150 lbs.		225 lbs.	
				Yield. Bushels per Acre.	%	Yield. (control) Bushels per Acre.	%	Yield Bushels per Acre.	%
1928	Pingrup, Solly Bros., light loam	1,099	1,410	25.8	93	27.7	100	28.0 (one plot only)	101
1928	North Kununoppin, A. E. Hughes, friable loam	668	*	15.0	88	17.0	100	15.8 Considerable variations due to hard patches	93
1930	Pingrup, O. C. Tranter, 4th crop clay loam	1,106	1,578	16.8	90	18.6	100	18.6	100
1930	Kondinin, W. Trembath, red morrel soil	1,075	1,439	29.3	92	32.0	100	31.5	98
1933	Gnowangerup, R. M. Watterson, light land of apparently low fertility	1,158	1,500	9.6	84	10.7	100	11.0	97

* Not available.

For references to Farmers' Trials, see *Jour. Agric., West. Aust.*, as follows:—

1928—Pingrup: Vol. 6, March, 1929, page 128.

1928—North Kununoppin: Vol. 6, March, 1929, page 178.

1930—Pingrup: Vol. 8, June, 1931, page 202.

1930—Kondinin: Vol. 8, March, 1931, page 154.

1933—Gnowangerup: Vol. 11, March, 1934, page 51.

(b) *The Present Experiments.*

The current series of experiments was organised in 1928 and first planted in 1929. These resembled the 1923-1928 experiments, but were designed to include plots receiving no superphosphate each year and a higher application. Rates of superphosphate under test were none, 75, 150, 225, and 300 lbs. per acre.

For convenience in the field, the experiment was divided into two groups, each of three treatments, using 150 lbs. of superphosphate per acre as the common control. One group, the low phosphate group, consisted of no superphosphate, 75 lbs. and 150 lbs. of superphosphate per acre. The high superphosphate group consisted of applications of 150, 225, and 300 lbs. per acre. Treatments were

TABLE 3.

1929 SERIES—AVERAGE YIELDS OF WHEAT GRAIN IN BUSHELS PER ACRE FROM PLOTS RECEIVING SUPERPHOSPHATE AT VARIOUS RATES PER ACRE. EACH PLOT HAS CONSISTENTLY RECEIVED THE SAME SUPERPHOSPHATE TREATMENT SINCE THE COMMENCEMENT OF THE EXPERIMENTS IN 1929. TO FACILITATE THE COMPARISONS EACH YIELD IS ALSO EXPRESSED AS A PERCENTAGE OF THE CONTROL DRESSING OF 150 LBS. OF SUPERPHOSPHATE PER ACRE.

Station.	Period.	No. of Crops Considered.	No Superphosphate.		75 lbs. per Acre.		150 lbs. per Acre. (Control)		225 lbs. per Acre.		300 lbs. per Acre.	
			Bushels per Acre.	Percentage of Control.	Bushels per Acre.	Percentage of Control.	Bushels per Acre.	Percentage of Control.	Bushels per Acre.	Percentage of Control.	Bushels per Acre.	Percentage of Control.
A. Chapman ...	1929-42	14	11.6	82	13.5	96	14.1	101	14.2	101	14.5	104
B. Dampawah ...	1929-39	10	6.6	45	13.6	92	14.8	101	15.0	101	15.1	102
C. Wongan Hills†	1929-42	13	4.2	20	16.5	82	20.5	103	21.1	103	21.3	104
D. Merredin* ...	1929-42	12	13.1	60	20.2	93	21.8	103	22.4	103	22.7	104
E. Yilgarn ...	1929-39	10	8.9	55	13.8	85	16.2	101	16.4	101	16.4	101
F. Salmon Gums ...	1929-42	14	6.9	47	13.1	89	14.8	104	15.4	104	15.6	105

* No harvest 1940 owing to complete crop failure under drought conditions. Harvester yields incomplete in 1939 owing to severe lodging.
 † 1937 crops destroyed by hail.
 Data discarded.

replicated five times, but were not randomised, so statistical treatment has not been applied. Of course, the control plots have not yielded exactly the same in each group, but on the average the yields have been very similar.

A summary of the results from the experiments on each station is given in Table 3. To make the comparison simple, in Table 3 the actual average yields are given for the low phosphate group but, for the heavy phosphate group, the control yield is adjusted to equal that of the control in the low phosphate group and the same percentage adjustment applied to the yields from the other treatments.

The actual yields are given in detail in the appendix, Tables A, B, C, D, E, and F.

The results show increasing yield with increasing superphosphate application up to 300 lbs. per acre, the maximum dressing used, but the differences above 150 lbs. of superphosphate per acre are too small to be of practical significance as far as the wheat yield is concerned.

The important consideration is the financial return from the fertiliser used. The rate per acre which will give the maximum nett monetary return per acre is most desirable for the farmer, and is known as the optimal dressing. This may be arrived at by deducting from the value of the total yield for each treatment the total cost involved.

In this paper it is assumed that:—

- (a) The value of the wheat on the farm after deducting handling and marketing charges is 3s. 4d. per bushel.
- (b) The cost of superphosphate on the farm is £5 per ton.
- (c) the operational and administrative costs per acre do not vary with the yield.

This leaves the cost of the superphosphate as the only variable and the nett value of the wheat grown on an acre will, therefore, be obtained by deducting the cost of the fertiliser used. On the basis of these assumptions the graphs in figure 1 have been constructed, and show the results for Chapman, Wongan Hills, and Merredin. The highest point of the nett value graph gives the optimal dressings. For 22 per cent. superphosphate these are of the order of magnitude of:—

Chapman Research Station	80 lbs. per acre.
Wongan Hills Research Station	130 lbs. per acre.
Merredin Research Station	110 lbs. per acre.

By a similar procedure the optimal dressings for the other research stations are:—

Dampawah Research Station	100 lbs. per acre.
Yilgarn Research Station	130 lbs. per acre.
Salmon Gums Research Station	110 lbs. per acre.

Somewhat lower figures for optimal dressings of superphosphate were obtained from experiments commenced in 1941 and 1942. (Figure 2.) These were as follows:—

Chapman	No response to superphosphate—weed competition very severe.
Wongan Hills	85 lbs. per acre.
Merredin	60 lbs. per acre.
Salmon Gums	80 lbs. per acre.

This shows that the superphosphate applied since 1929 has improved the phosphate status of the soils and indicates that the optimal rates tend to decline as the total amount of superphosphate previously applied increases.

The elimination of superphosphate on new land on the research stations has given greatly reduced yields, even disastrous results. At Chapman and Wongan Hills, on light land not previously cropped, a complete failure resulted from withholding superphosphate. On stronger soil types such as at Salmon Gums, Dampawah, and Yilgarn, the reduction was about 50 per cent. That similar results would have been obtained at Merredin is indicated by the report of Clifton (1905), p. 458, concerning the first crop sown on the station in 1905. "One hundred and five pounds of superphosphate per acre was used as a fertiliser, but here and there throughout the crop a small strip has been left for comparative purposes. The difference between the crop of these strips and the fertilised land adjoining, otherwise dealt with in exactly the same manner, is as might be expected, very marked."

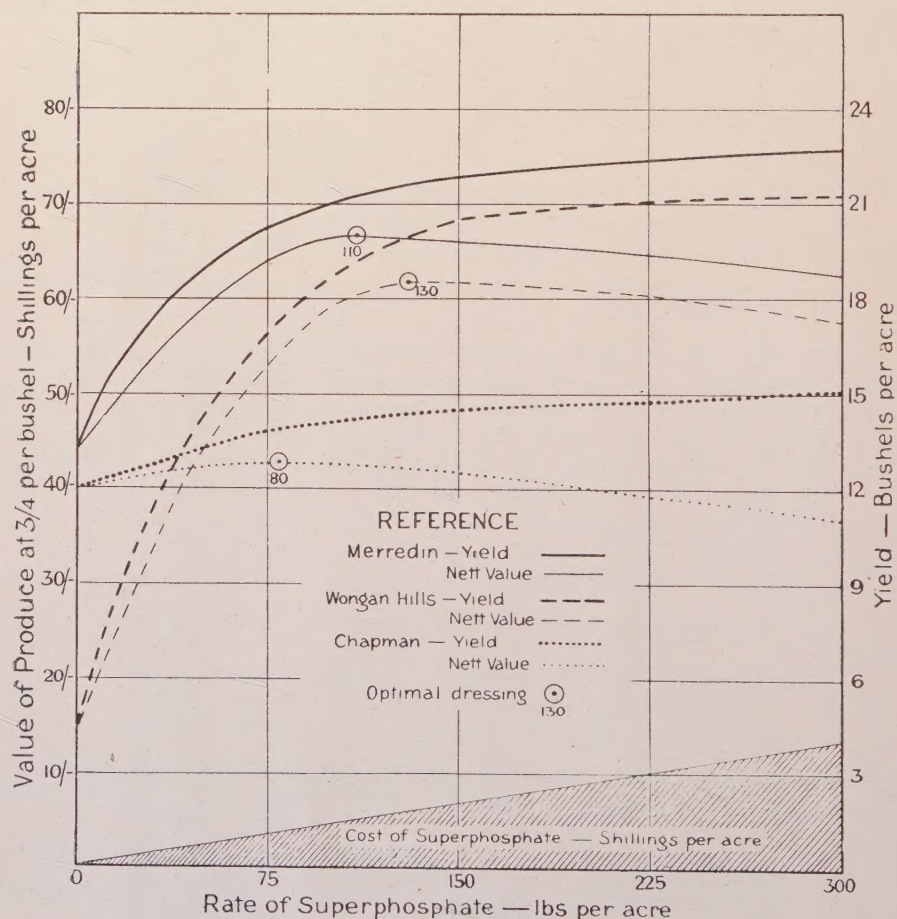


Fig. 1.

Effect of various rates of superphosphate on the yield of wheat and the net monetary return per acre. 1929 series.

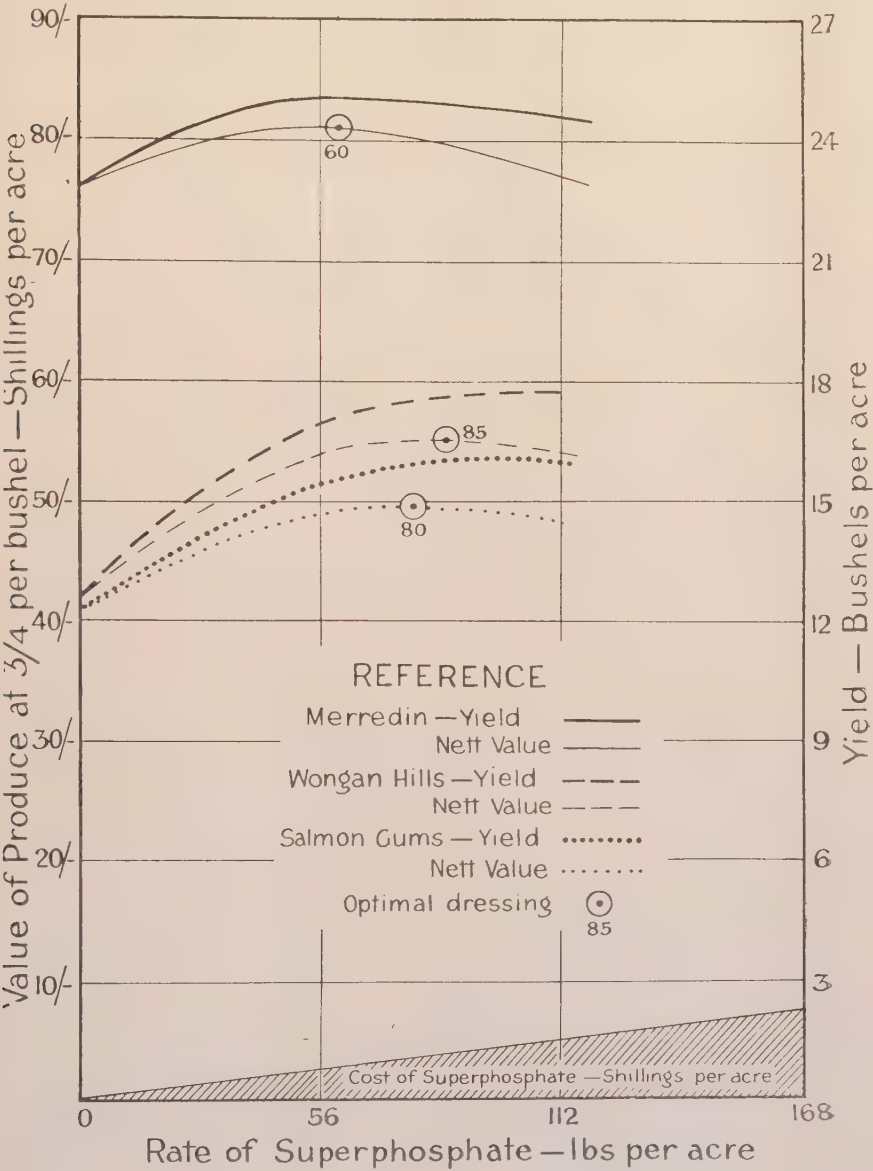


Fig. 2.

Effect of various rates of superphosphate on the yield of wheat and the net monetary return per acre. 1941 series.

On heavy soil types of the Merredin Research Station, which had carried several previous crops well fertilised with superphosphate, the reduction in yield of wheat with no fertiliser as compared with the crop receiving 150 lbs. of superphosphate per acre averaged 40 per cent. Least reduction in yield, 20 per cent., was observed on the Chapman Research Station. These soils would have received somewhat larger prior applications of superphosphate than on the Merredin Station. (See Tables 4, 5, 6, and 7 and A-F of Appendix.)

YIELDS OF SUCCESSIVE WHEAT CROPS GROWN ON THE SAME PLOTS WITHOUT SUPERPHOSPHATE.

Year.	Rate of Superphosphate Application (lbs. per Acre).			No Superphosphate as Percentage of :	
	None.	75.	150.	75 lbs.	150 lbs.
	bush. per acre.	bush. per acre.	bush. per acre.	%	%

Table 4.—CHAPMAN RESEARCH STATION, 1929-1942.

Paddock 21 (cleared 1914)—

Six previous crops—total superphosphate, 500 lbs. per acre.

1929	...	...	8.1	9.7	11.3	84	72
1932	...	...	7.0	9.4	11.0	74	64
1934	...	...	5.6	6.6	7.4	85	76
1936	...	...	14.7	15.2	15.1	97	97
1941	...	...	11.8	12.1	13.6	98	87

Paddock 19—

Eight crops since 1911—total superphosphate, 626 lbs. per acre.

Known prior crops in 1903, 1904, 1906, etc., received a total of 300 lbs. of superphosphate.

1930	...	...	13.1	13.4	13.6	98	96
1933	...	...	10.4	11.6	11.8	90	88
1938	...	...	12.4	15.8	14.9	78	83
1940	...	...	15.6	19.8	20.1	79	78
1942	...	...	8.9	9.0	8.5	99	105

Paddock 6A—

Seven crops since 1910—total superphosphate, 632 lbs. per acre.

Known prior crop in 1904 received 112 lbs. of superphosphate per acre.

1931	...	...	13.7	17.6	19.8	78	69
1935	...	...	13.7	17.3	19.3	79	71
1937	...	...	11.6	12.5	12.8	93	91
1939	...	...	16.4	18.5	18.0	89	91

Table 5.—WONGAN HILLS RESEARCH STATION, 1929-1942.

Paddock 1E—

Cropped 1926 and 1928—total superphosphate, 262 lbs. per acre.

1932	...	...	12.6	20.8	22.7	61	56
1934	...	...	9.3	22.4	25.1	42	37
1937	...	...	crop destroyed by hail				
1941	...	...	12.2	24.4	25.9	50	47

Paddock 4H—

Cropped 1930—total superphosphate, 150 lbs. per acre.

1938	...	...	7.8	21.3	25.6	37	30
1942	...	...	7.1	21.6	23.2	33	31

Paddock 2E—

No previous crops or fertiliser applications.

1929	...	...	Nil	5.9	8.7	...	...
1931	...	...	Nil	10.6	15.8	...	...
1935	...	...	Nil	17.5	25.0	...	...
1939	...	...	1.3	10.6	14.2	12	9

Paddock 3E—

No previous crops or fertiliser applications.

1930	...	...	Nil	12.5	15.2	...	...
1933	...	...	Nil	11.9	16.8	...	...
1936	...	...	Nil	19.8	24.0	...	...
1940	...	...	3.8	20.8	24.9	18	15

YIELDS OF SUCCESSIVE WHEAT CROPS GROWN ON THE SAME PLOTS WITHOUT SUPERPHOSPHATE—*continued*.

Year.	Rate of Superphosphate Application (lbs. per Acre).			No Superphosphate as Percentage of :	
	None.	75.	150.	75 lbs.	150 lbs.
	bush. per acre.	bush. per acre.	bush. per acre.	%	%

Table 6.—MERREDIN RESEARCH STATION, 1929-1942.

Paddock 3—

Six crops, 1911-1928—total superphosphate, 524 lbs. per acre.

Known prior crops in 1906, 1908, probably received total of 150 lbs. of superphosphate per acre.

1929	...	...	20.0	25.1	27.2	80	74
1932	...	...	10.7	22.9	25.4	47	42
1934	...	...	13.2	21.9	25.0	60	53
1936	...	...	3.2	5.7	5.7	56	56
1938	...	...	7.6	12.2	13.3	62	57
1940	...	...	...	No crop account drought		...	...

Paddock 5—

Six crops, 1911-1928—total superphosphate applied, 612 lbs. per acre.

Known prior crop in 1910 received 112 lbs. of superphosphate per acre.

1931	...	...	19.5	26.9	27.4	72	71
1933	...	...	13.4	18.9	21.7	71	62
1935	...	...	6.6	11.1	12.9	59	51
1942	...	...	21.6	25.6	26.7	84	81

Paddock 8—

Seven crops, 1911-1928—total superphosphate applied, 492 lbs. per acre.

Probably a prior crop in 1909 which would have received 1 cwt. of superphosphate per acre.

1930	...	...	12.9	25.2	28.1	51	46
1937	...	...	8.4	14.0	14.3	60	59
1939	...	...	...	lodging upset results		...	...
1941	...	...	19.9	33.0	33.8	60	59

Table 7.—SALMON GUMS RESEARCH STATION, 1929-1942.

Paddock A1—

Cropped 1927—total superphosphate applied, 90 lbs. per acre.

1929	...	...	5.0	14.4	15.6	35	32
1931	...	...	8.3	15.6	15.6	53	53
1933	...	...	5.5	13.0	18.0	42	31
1935	...	...	11.4	13.0	15.3	88	75
1937	...	...	9.6	13.3	15.5	72	62
1939	...	...	8.6	14.7	17.8	59	48

Paddock A3—

Cropped 1927, 1929, and 1931—total superphosphate applied, 290 lbs. per acre.

1936	...	...	3.9	7.2	8.8	54	44
1938	...	...	9.5	18.4	17.7	52	54
1940	...	...	2.0	2.8	3.2	71	62
1942	...	...	8.8	14.6	17.0	60	52

Paddock B1—

Cropped 1928—total superphosphate applied, 90 lbs. per acre.

1930	...	...	8.2	12.7	13.9	65	59
1932	...	...	7.3	22.9	24.2	32	30
1934	...	...	2.8	9.4	12.5	30	22
1941*	...	...	5.8	11.2	12.5	52	46

* Four plots only.

It may be concluded that there is no need to use more than 150 lbs. of 22 per cent. superphosphate for maximum wheat returns on Western Australian soils. In fact, on the forest and mallee soils it is probable that a dressing of the order of magnitude of 1 cwt. per acre is adequate. Up to 150 lbs. per acre may prove profitable on the light soil types. Where the land has been well farmed and fertilised for many years these rates could be considerably reduced.

If more is applied the superphosphate is not wasted. It is not washed out by the rains as nitrate of soda would be, but is absorbed by the soil to build up reserves which are slowly available. These are of great value for subsequent cereal and pasture crops, particularly if a small amount of superphosphate is applied at seeding, for sown crops, or in the autumn for pastures.

2. What is the residual value of the superphosphate not actually absorbed by the crop?

From the information derived from the examination of Western Australian material, it is apparent that only a fraction of the superphosphate applied with the crop is actually absorbed by the growing plants. A 20-bushel wheat crop will take up the equivalent of one-third of the phosphate applied in a dressing of 100 lbs. of 22 per cent. superphosphate per acre. The remainder is absorbed by the soil.

Soils have a remarkable capacity for absorbing water soluble phosphate and it is only under exceptional conditions that losses occur through the leaching action of water. The bulk of the superphosphate not absorbed by the crop remains in the surface soil. Only when the surface soil is removed by erosion is there a loss of the phosphate.

The capacity of a soil to absorb phosphate may be likened to the soaking up of water by a sponge. A sponge will take up water until the pores are full—when it is saturated. As the sponge approaches saturation the water becomes increasingly easy to remove by squeezing. With respect to the soil the amount of phosphate needed for saturation will depend on its properties, particularly the nature of the clay fraction, the organic matter, the lime content, the amount of iron, aluminium and similar oxides, etc. As saturation is approached the phosphate becomes more loosely held and thus more readily available to the crop.

In many parts of the world, some soils are sufficiently saturated naturally for most crops to obtain adequate supplies of available phosphate without the addition of phosphatic fertilisers. Others will not grow certain crops unless well fertilised with superphosphate. Unfortunately, most Western Australian soils are, in the virgin state, very poorly supplied with available phosphate and crops need superphosphate from the very outset for maximum production, to enable the plant to take up its initial needs before the soil has completely absorbed the fertiliser and rendered it slowly available.

There is little evidence regarding the amounts of superphosphate required to saturate the various wheat soils of Western Australia. It is known, however, that more is needed for the ironstone gravel soils such as occur at Wongan Hills than on the timber and mallee types represented by the other stations.

These latter types seem to show small response, probably about 10 per cent. increase in yield, to superphosphate when about half a ton of superphosphate per acre has been applied with previous crops. Some South Australian soils are reported to require about 15 cwt. of superphosphate per acre before the crop

is able to satisfy its phosphate needs without fertilisation. The heavy red loams of northern New South Wales appear able to absorb as much as 90 tons of superphosphate per acre foot of soil.

With soils of moderate phosphate absorption capacity it is desirable to meet the phosphate requirements as soon as possible by liberal fertiliser applications. This amounts to building up capital reserves. Yield reductions with wheat crops sown with small amounts of, or even without superphosphate in cases of necessity, are generally small where the land has received liberal amounts with previous crops.

The yield reductions of series of crops sown without superphosphate on land which had received superphosphate with a number of previous crops are shown in Tables 4, 5, 6, and 7.

Of these, the figures for Wongan Hills (Table 5) are most interesting and important as on this station the yield of wheat on virgin land without superphosphate is nil. On virgin land in paddocks 2E and 3E, no crop was obtained from the first three sowings in each case, but movement of the phosphate-treated soil from adjacent plots permitted a slight production of wheat in the fourth season. By contrast, on land in paddock 1E, which had received 262 lbs. of superphosphate per acre, and in paddock 4H, 150 lbs. per acre, prior to the commencement of the experiment the average yields were 11.4 and 7.4 bushels per acre, respectively. Of course, these yields are not high, but are not the complete failures which are obtained on virgin land of this type.

To determine the effect of sowing wheat without superphosphate and with small dressings (56 and 112 lbs. per acre) on land which had received considerably more superphosphate as a result of cropping subsequent to 1928, a further series of experiments was commenced on the Chapman, Wongan Hills, Merredin, and Salmon Gums Research Stations in 1941. The results are given in detail in Table 8. The optimal applications are indicated in figure 2.

These results show a substantial increase in the relative yield of wheat on the plots receiving no superphosphate, as compared with the 1929 series of experiments. This increase is undoubtedly due to the larger superphosphate residues accumulated since 1928. Table 9 illustrates this increased residual value.

The 1941 series figures are calculated to 75 lbs. of superphosphate per acre from the data for 56 and 112 lbs. per acre, as illustrated in figure 2. In the 1929 series only the data for the first crops without superphosphate are used.

This increased residual value of higher dressings of superphosphate is illustrated by an experiment conducted in 1915-1921 at the Merredin Research Station. (See Table 1.) In 1921 the experimental area was sown with no superphosphate, and the yields after the different treatments compared.

Prior to the commencement of this experiment the land had received 320 lbs. of superphosphate per acre. In 1921, the yield on the plots which had received no superphosphate with the 1915, 1917, and 1919 crops was 20.6 bushels per acre, 90 per cent. of the yields with no superphosphate on the plots dressed in 1915, 1917, 1919 with 1 cwt. per acre. The plots receiving 56 lbs. per acre in this period and none in 1921 yielded 96 per cent. of those which had received the hundred-weight.

Maintenance of Yields on Plots receiving no Superphosphate.

The yields on the plots receiving no superphosphate have been well maintained for a number of crops since the inception of the rate of superphosphate experi-

TABLE 9.

ESTIMATED RELATIVE YIELDS OF WHEAT ON PLOTS RECEIVING NO SUPERPHOSPHATE FOR THE FIRST TIME IN THE 1929 SERIES AS COMPARED WITH THE 1941 SERIES. YIELDS ON PLOTS RECEIVING 75 LBS. OF SUPERPHOSPHATE PER ACRE ARE ADOPTED AS CONTROLS.

Research Station.	Paddock.	Superphosphate Applications.		Percentage Yields on "no Superphosphate" Plots as compared with 75 lbs. per acre Plots.			
		Additional since commencement of 1929 Series.	Estimated Total prior to commencement of 1941 Series.	1929 Series.		1941 Series.	
				Year.	%	Year.	%
Chapman	6A	lbs. per acre. 448	lbs. per acre. 1,192	1931	78	...	...
	19	448	1,374	1930	98	1942	102
	21	560	1,060	1929	84	...	...
	Average	...	...	...	87	...	102
Wongan Hills	1E	485	747	1932	61	1941	77
	4H	120*	270	1938	37	1942	67
	Average	...	...	...	49	...	72
Merredin	3	672	1,350	1929	80	1942	90
	5	336	1,060	1931	72	1942	88
	8	374	970	1930	51	1941	92
	Average	...	...	...	68	...	90
Salmon Gums	A1	672	762	1929	35	...	...
	A3	448	738	1936	54	1942	78
	B1	448	538	1930	65	...	...
	Average	...	...	...	51	...	78

* In 1938, which was the first year of the 1929 Series in this paddock, No subsequent additions were made.

ments in 1929. The data in Tables 4, 5, 6, and 7, show no evidence of deterioration in percentage yield even after as many as six crops. Just how many crops, yielding about 50 per cent. of the fertilised plots, may be carried can only be determined by continued experimentation.

It is known that such factors as the manurial action of grazing stock and soil movement due to cultivation and wind action do contribute to the maintenance of yields on the unfertilised plots which lie adjacent to well-fertilised areas. This is established by observations at Wongan Hills on the no superphosphate plots in paddocks 2E and 3E which had not received superphosphate prior to the initiation of the experiment. For three crops there was no harvestable crop on these plots, but in the course of time the edges adjacent to the fertilised plots made more growth than the centres. The fourth crop, planted ten years later in each case, showed a small but definite yield. Plots on 2E yielded 1.3 bushels (9 per cent. of the 150 lbs. per acre plots) and on 3E, 3.8 bushels (15 per cent.). At Merredin the no fertiliser plots still stand out uniformly at flowering time owing to slightly delayed maturity, although yield differences are small (7 per cent.) in the case of the 1941 series. It is considered that the addition of phosphate by the above factors to the no superphosphate plots is real but not substantial and does not invalidate the conclusions drawn from these data.

3. What will be the effect of reducing the rate of application of superphosphate on the yield of wheat?

As the rate of application of superphosphate is reduced below the optimal levels indicated by the experiments discussed above, the yield of wheat will be reduced. On old, well fertilised land the reduction in the first crop will be small. Complete elimination of superphosphate under experimental conditions has effected a loss ranging from 25 to 35 per cent. on light land and from nil to 25 per cent. on medium and heavy land.

The reduction with applications of 40 lbs. of 18 per cent. superphosphate is not likely to exceed 25 per cent. except on relatively new land and very light soils, and on the medium and stronger soil types yields will probably exceed 90 per cent. of the optimal dressing, as least for the first crop or two. Crop failure due to such a small application of superphosphate need not be feared.

The phosphate needs of a 20-bushel crop of wheat will be just met by 40 lbs. of the 18 per cent. superphosphate being marketed. There will be no residual amount which would be valuable for succeeding pastures. Where these pastures are improved types such as subterranean clover and burr trefoil an annual top-dressing with the superphosphate, if procurable for the purpose, should be practised.

¹ E.—THE USE OF THE SUPERPHOSPHATE RATION.

The superphosphate supply should be spread over the whole acreage for which the ration is granted. It should not be concentrated on a portion of the area being sown or for which topdressing has been allowed.

Of course, this will involve certain extra costs and the return *per acre* actually dressed with the reduced rate of application of superphosphate will be less; but more food will be produced for each ton of superphosphate and from each farm. Quantity of production, especially of grassland products, is vitally important at present.

It is well established that the greatest crop response is obtained from the first fraction of a fertiliser application. That is, the first 40 lbs. of superphosphate will give a greater yield increase than will the second 40 lbs. if the application is brought up to 80 lbs. per acre for a comparison. This observation has been embodied in the Law of Diminishing Returns which is the basis for any programme of fertiliser rationing.

A quantity of readily available or water soluble phosphate is of prime importance to the seedling to promote rapid early growth and root development. In consequence, superphosphate should be applied at seeding time to ensure a vigorous start and an extensive root system which will be able to make utmost use of the slowly available phosphate in the soil. It has been shown under experimental conditions that wheat, generously supplied with available phosphate in the first four to six weeks of its growth, may absorb sufficient phosphate to produce a heavy crop without access to any further supply. Under these conditions the phosphate content of the plant is exceptionally low without impairment of the growth. The low phosphate content of Western Australian wheats and straws indicates that the plants probably enjoy a luxury phosphate level for a short period, but the rate of intake in the later growth stages is greatly restricted owing to the rapid absorption of the water soluble phosphate by the soil.

This supply of water soluble phosphate for the wheat seedling is important to promote early maturity. Even where little difference in yield between unfertilised plots and those receiving superphosphate is observed at harvest, the quicker growth with readily available phosphate is quite marked during the growing period. Even a few days advantage in maturity may be important in the avoidance of certain diseases or dry spring conditions common in Western Australia.

An experiment carried out on the research stations in the period 1928-1931, showed a yield advantage in favour of superphosphate application at seeding. Adopting a total application of 225 lbs. of superphosphate per acre in the 1928-31 series, some or all was applied in March and the remainder, if any, at seeding. The yields are given in Table 10.

A somewhat similar experiment was carried out in 1941-42. In July of 1941 an area of fallow in paddock 5 was dressed with superphosphate at the rate of 112 lbs. per acre.

This treatment was deemed to represent the effect of a drought and complete crop failure. In 1942 an experiment was planted with wheat on this area using superphosphate at 56 and 112 lbs. per acre in comparison with no superphosphate. The results were:—

No superphosphate	..	..	23.7 bushels per acre (96%).
56 lbs. per acre	..	..	23.8 bushels per acre (96%).
112 lbs. per acre (control)	..	..	24.7 bushels per acre (100%).

It is most likely that these differences are due to experimental error. The land had received a little more than 9 cwt. of superphosphate per acre prior to the July dressing in 1941, and the residual value of these earlier dressings would largely account for the high yields of the no superphosphate plots. It is difficult to differentiate the effect of the July, 1941, application.

F.—DISCUSSION.

Contrary to the belief of many farmers, there is no evidence of danger of crop failure due to lack of superphosphate when wheat is grown without super-

TABLE 10.
EFFECT OF TIME OF APPLICATION OF SUPERPHOSPHATE ON THE YIELD OF WHEAT ON THE AGRICULTURAL RESEARCH STATIONS.
Four Crops,—1928-1931—Total Superphosphate 225 lbs. per Acre with each Crop.

Research Station.	Paddocks Cropped.	Application of Superphosphate.				
		150 lbs. at Seeding. 75 lbs. in March.		75 lbs. at Seeding. 150 lbs. in March.		Percent ge of 150 lbs. at Seeding.
		Yield.	Per cent.	Yield.	225 lbs. in March.	
		bush. per acre.		bush. per acre.	Yield.	bush. per acre.
Chapman		14.7	100	13.9	13.8	94
Dampawah (2 crops)		14.0	100	13.8	13.2	94
Wongan Hills		19.1	100	18.3	17.0	89
Merredin		25.7	100	25.5	24.1	94
Yilgarn		17.9	100	16.8	16.5	92
Salmon Gums		14.7	100	14.1	13.3	90

PREVIOUS SUPERPHOSPHATE DRESSINGS PER ACRE.

CHAPMAN—6A—Six previous crops since 1911, 520 lbs. of superphosphate; 18A and 19—Eight previous crops since 1911, 18A—702 lbs. of superphosphate; 19—626 lbs. of superphosphate.
DAMPAWAH—None.
WONGAN HILLS—1E—One previous crop, 112 lbs. of superphosphate; 2E and 3E—None.
MERREDIN—3—Six previous crops since 1911, 524 lbs. of superphosphate; 5—Six previous crops since 1910, 612 lbs. of superphosphate; 8—Seven crops since 1911, 492 lbs. of superphosphate.
YILGARN—None.
SALMON GUMS—A1—90 lbs. of superphosphate; B1—None.

phosphate on old well-prepared land, previously well fertilised. Maximum yields are not obtained, but the reduction is small.

When small applications of superphosphate are used the yield reduction will be considerably less.

This is established by the results of numerous experiments carried out during the past forty years under a wide range of conditions representative of the wheat belt. All of this work has been carried out under field conditions using methods similar to those commonly adopted and proved as good farming practice throughout the wheatbelt. In all cases the experimental areas received the same cultural treatments and the only differences involved were the rates of superphosphate applied.

The data presented and discussed in this paper leave little room for doubt.

It may be argued that the small field plots used—one-eighth of an acre in area—although replicated five times for each treatment, are not truly representative of field conditions. This argument is unsound.

Study of the yields of wheat at the Research Stations in 1942, with superphosphate reduced to 60 to 70 lbs. per acre, or approximately two-thirds of the normal, gives no reason to suppose that this reduction has adversely affected the returns. In fact, the yield per inch of rain during the growing period at Merredin, Salmon Gums, and Avondale, has even been somewhat higher in 1942 with a lower rate of superphosphate than in the most recent year for which valid comparison is possible. At Merredin, in 1941, the 74 acres of the variety Bencubbin yielded 27.8 bushels per acre—2.7 bushels per inch of rain during the growing period. In 1942, the 58 acres under the same variety, growing on a similar soil type and planted at the same time, yielded 23.3 bushels per acre—2.8 bushels per inch of rain during the growing period. The growing period rainfall in 1942 was 1.8 inches lower than in 1941. At Salmon Gums the yield of wheat on the farm in 1942 (45 acres) was 20.1 bushels per acre—2.1 bushels per inch of rain in the growing period. The 1940 and 1941 crops practically failed owing to drought conditions, but in 1938 growing conditions were very similar to 1942. In that year the wheat yield on the station was 21.1 bushels per acre—1.9 bushels per inch of rain in the growing period. In 1939, a less favourable season, the production of wheat per inch of rain was 2.0 bushels. At the Avondale Research Station, Beverley, the figures show that the yields of wheat were somewhat higher per acre and per inch of rain in 1942 than in 1941 when the seasonal and cultural conditions were similar.

On the other hand, at Wongan Hills, the yield of wheat in 1942 with a higher rainfall, was somewhat lower than in 1941, 12.9 bushels per acre as compared with 13.9. This is in keeping with the usual experience of an inverse relationship between yield and rainfall on this station. The yield of wheat per inch of growing period rain was 1.05 bushels in 1942 and 1.29 in 1941.

In presenting these figures it must be pointed out that great caution must be exercised in the comparison of crop production in different seasons. These results, however, indicate that no decrease in yield has resulted which can be attributed to the use of reduced dressings of superphosphate in 1942.

Many farmers will raise the question of the effect of reduced superphosphate dressings with the wheat crop on the succeeding pasture. No experimental data are available from these experiments and the matter is, therefore, not discussed. Observations are planned for 1943.

TABLE A.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.
Chapman Research Station.—Rate of Superphosphate Experiment 1929-1942.

Year.	Pad- dock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.									
				Low Superphosphate Group.					High Superphosphate Group.				
		Annual.	May- Oct.	No Superphosphate.	75 lbs. per Acre.		150 lbs. per Acre. (Control)		225 lbs. per Acre.		300 lbs. per Acre.		
					bushels	%	bushels	%	bushels	%	bushels	%	
1929	21	1,783	1,554		8.1	72	11.3	100	15.2	112	15.0	110	
1930	19	1,965	1,856		13.1	96	13.6	100	11.9	99	10.9	91	
1931	6A	2,009	1,755		13.7	69	17.6	100	19.9	107	20.6	111	
1932	21	2,044	1,716		7.0	64	9.4	100	10.7	95	12.1	113	
1933	19	2,174	1,883		10.4	88	11.6	100	12.0	95	12.7	101	
1934	*21	2,370	1,348		5.6	76	6.6	100	5.9	113	4.7	90	
1935	6A	1,405	1,013		13.7	71	17.3	100	15.1	93	15.7	96	
1936	21	1,593	1,427		14.7	97	15.2	100	16.8	104	19.2	118	
1937	6A	1,561	1,417		11.6	91	12.5	100	13.5	113	13.5	113	
1938	19	1,306	939		12.4	83	15.8	100	14.6	95	13.4	87	
1939	6A	2,575	2,101		16.4	91	18.5	100	18.8	97	19.4	100	
1940	19	1,237	1,132		15.6	78	19.8	100	22.1	101	22.0	100	
1941	21	1,802	1,474		11.8	87	12.1	100	12.6	102	13.1	107	
1942	†19	1,783	1,527		8.9	105	8.5	100	9.0	92	9.2	94	
Average, 14 crops	...	...	...	11.6	13.5	96	14.1	100	14.1	101	14.4	103	
Value of Wheat at 3s. 4d. per bushel	...	...	...	s. d.	45 0		s. d.		s. d.		s. d.		
Cost of Superphosphate	...	...	...		3 4		46 8		47 0		48 0		
Net Value of Wheat	...	...	...	38 8	41 8		6 8		10 1		13 5		
							40 0		36 11		34 7		

* Severe damage from rust.

† Severe damage from weeds, especially with the higher rates of superphosphate.

Superphosphate applications, 1910-1928 period and known previous applications from available data:—

Padlock 21 (cleared 1914).—6 crops, total superphosphate 500 lbs. per acre.

Padlock 19 (cleared 1902).—8 crops, 1911-28 period, total superphosphate 626 lbs. per acre; 3 known crops, 1903-10 period, total superphosphate 800 lbs. per acre.

Padlock 6A (cleared 1903).—7 crops, 1910-28 period, total superphosphate 632 lbs. per acre; 1 probable crop, 1903-10 period, total superphosphate 112 lbs. per acre.

TABLE B.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.
Dampaw Research Station—Rate of Superphosphate Experiment—1929-1939.
No superphosphate applications prior to commencement of the experiment.

Year.	Pad-dock.	Rainfall Points.	Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.						High Superphosphate Group.					
			Low Superphosphate Group.			150 lbs. per Acre. (Control)			225 lbs. per Acre.			300 lbs. per Acre.		
			Annual.	May-Oct.	No Superphosphate.	75 lbs. per Acre.	150 lbs. per Acre. (Control)	150 lbs. per Acre. (Control)	225 lbs. per Acre.	225 lbs. per Acre.	225 lbs. per Acre.	300 lbs. per Acre.	300 lbs. per Acre.	300 lbs. per Acre.
					bushels	%	bushels	%	bushels	%	bushels	%	bushels	%
1929	A	1,095	674		7.0	34	20.8	100	21.0	100	20.8	99	21.5	102
1930	B	1,069	768		5.3	65	8.2	100	6.2	100	5.1	82	15.1	82
1931	C	1,187	848		6.5	62	10.5	100	9.7	100	9.2	95	15.1	95
1932	A	1,156	920		6.7	37	16.5	100	17.6	100	17.8	101	18.5	105
1933	B	1,655	1,394		13.4	68	19.8	100	19.4	100	20.2	104	20.5	106
1934	C	1,308	672		6.3	28	22.4	100	21.5	100	22.4	104	22.2	103
1935	A	1,212	508		3.8	28	11.2	100	12.8	100	14.0	109	13.6	106
1936	C	940	544		5.3	46	10.0	100	10.7	100	10.3	96	10.0	93
1937	A	873	668		N/	...	2.3	82	4.2	100	4.5	107	4.4	105
1938	C	590	400		12.1	62	19.6	100	16.0	100	16.6	104	17.3	108
1939	B	1,952	1,221		6.6	45	13.6	92	13.9	100	14.1	101	14.2	102
Average 10 crops ...		...	...	...	s. d.		s. d.		s. d.		s. d.		s. d.	
Value of Wheat at 3s. 4d. per bushel ...		...	...	...	22 0		49 4		47 0		47 0		47 4	
Cost of Superphosphate ...		...	...	...	...		6 8		10 1		10 1		13 5	
Net Value of Wheat ...		...	...	...	22 0		42 8		36 11		36 11		33 11	

* Calculated from result obtained in high superphosphate group.
assumed to avoid weighting the average in favour of 300 lbs. per acre.
† No yield data. Yield for 225 lbs. of superphosphate per acre
Hay Yields, 1936.—No superphosphate, 0.8 cwts. per acre (6 per cent.); 75 lbs. per acre, 11.7 cwts. per acre (89 per cent.); 150 lbs.
per acre, 13.1 cwts. per acre (100 per cent.).

TABLE C.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.
Wongan Hills Research Station.—Rate of Superphosphate Experiment—1929-1942.

Year.	Pad- dock.	Rainfall Points.	Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.									
			Low Superphosphate Group.					High Superphosphate Group.				
			No Superphosphate.	75 lbs. per Acre.	150 lbs. per Acre. (Control)	150 lbs. per Acre. (Control)	150 lbs. per Acre. (Control)	225 lbs. per Acre.	300 lbs. per Acre.	225 lbs. per Acre.	300 lbs. per Acre.	
		Annual.	May- Oct.	% bushels	% bushels	% bushels	% bushels	% bushels	% bushels	% bushels	% bushels	
1929	2E	1,541	1,175	Nil	5.9	68	8.7	100	8.4	100	9.2	110
1930	3E	1,299	1,048	Nil	12.5	82	15.2	100	15.4	100	15.8	103
1931	2E	1,291	1,038	Nil	10.6	67	15.8	100	20.6	100	22.9	111
1932	1E	1,334	1,267	56	20.8	92	22.7	100	20.4	100	20.8	102
1933	3E	1,353	1,260	Nil	11.9	71	16.8	100	16.7	100	17.3	104
1934	1E	1,380	926	9.3	22.4	89	25.1	100	22.8	100	20.2	89
1935	2E	1,288	971	Nil	17.5	70	25.0	100	33.4	100	33.8	101
1936	3E	1,081	878	Nil	19.8	82	24.0	100	20.6	100	21.7	105
1937	1E	1,350	992	7.8	21.3	83	25.6	100	20.7	100	23.3	113
1938	4H	1,276	751	1.3	10.6	75	14.2	100	24.4	100	25.9	106
1939	2E	2,130	1,481	9	20.8	84	24.9	100	19.9	100	19.4	97
1940	3E	905	730	3.8	20.8	84	24.9	100	17.9	100	18.8	105
1941	1E	1,532	1,077	12.2	24.4	94	25.9	100	21.6	100	21.9	101
1942	4H	1,933	1,233	7.1	21.6	93	23.2	100	21.6	100	22.1	102
Average, 13 crops	...	...	...	4.2	16.9	82	20.5	100	20.2	100	21.0	104
Value of Wheat at 3s. 4d. per bushel	...	...	...	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	
Cost of Superphosphate	...	...	...	14 0	56 4	68 4	67 4	69 4	70 0	69 4	70 0	
Net Value of Wheat	...	...	...	...	3 4	6 8	6 8	6 8	10 1	6 8	13 5	
	...	...	...	14 0	53 0	61 8	60 8	59 3	56 7	59 3	56 7	

Superphosphate applications prior to commencement of the experiment :—
Paddock 2E and 3E—None ; Paddock 1E—2 crops, total superphosphate 262 lbs. per acre ; Paddock 4H—one—1 crop, total superphosphate 150 lbs. per acre.

TABLE D.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.
Merredin Research Station.—Rate of Superphosphate Experiment—1929-1942.

Year.	Pad- dock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.												
		Annual.	May- Oct.	Low Superphosphate Group.					High Superphosphate Group.							
				No Superphosphate.	75 lbs. per Acre.	150 lbs. per Acre. (Control)	150 lbs. per Acre. (Control)	225 lbs. per Acre.	300 lbs. per Acre.							
Average, 12 crops	...	...	...	13.1	bushels	%	bushels	%	bushels	%	bushels	%	bushels	%		
					20.0	74	25.1	92	27.2	100	25.3	100	25.4	100	25.6	101
					12.9	46	25.2	90	28.1	100	27.2	100	29.6	109	30.7	113
					19.5	71	26.9	98	27.4	100	29.1	100	29.3	101	29.4	101
					10.7	42	22.9	90	25.4	100	26.3	100	27.1	103	28.2	107
					13.4	62	18.9	87	21.7	100	25.8	100	27.0	105	27.0	105
					13.2	53	21.9	88	25.0	100	23.4	100	25.0	107	25.3	108
					6.6	51	11.1	86	12.9	100	12.7	100	13.7	108	13.4	106
					3.2	56	5.7	100	5.7	100	5.4	100	5.0	93	4.7	87
					8.4	59	14.0	98	14.3	100	16.4	100	15.7	96	15.9	97
					7.6	57	12.2	92	13.3	100	12.7	100	13.3	105	13.2	104
					23.9	...	30.2	...	*25.4	...	*23.9	...	*18.9	...	*16.8	...
Value of Wheat at 3s. 4d. per bushel ...	...	...	...	s. d.	No crop on account of drought conditions.											
					19.9	59	33.0	98	33.8	100	35.9	100	35.8	100	36.3	104
					21.6	81	25.6	95	26.7	100	27.5	100	27.8	101	28.5	104
Cost of Superphosphate ...	...	...	...	s. d.												
					20.2	60	21.8	93	22.3	100	22.9	103	23.2	104		
					67 4		72 8		s. d.		s. d.		s. d.			
Net Value of Wheat ...	...	...	...	43 8												
					3 4		6 8		6 8		10 1		13 5			
				43 8	64 0		66 0		67 8		66 3		63 11			

* Rank growth with high rates caused lodging and harvester returns incomplete—figures discarded.

Superphosphate applications, 1911-1928 period and known previous application— from available data :—
Paddock 3.—6 crops, 1911-1928 period, total superphosphate approximately 524 lbs.; 2 crops, 1906 and 1908, probably received a total of 150 lbs. of superphosphate per acre.
Paddock 5.—6 crops, 1911-1928 period, total superphosphate approximately 612 lbs.; 1 crop in 1910 received 112 lbs. of superphosphate per acre.
Paddock 8.—7 crops, 1911-1928 period, total superphosphate approximately 492 lbs.; probably one crop in 1909 received 112 lbs. of superphosphate per acre.

TABLE E.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.
Yilgarn Research Station.—Rate of Superphosphate Experiment—1929-1939.

Year.	Paddock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.											
		Annual.	May-Oct.	Low Superphosphate Group.					High Superphosphate Group.						
				No Superphosphate.	7½ lbs. per Acre.	150 lbs. per Acre. (Control)	150 lbs. per Acre. (Control)	225 lbs. per Acre.	300 lbs. per Acre.						
1929	E	1,071	571	bushels 6.5	% 58	bushels 10.4	% 93	bushels 11.2	% 100	bushels 7.4	% 100	bushels 6.0	% 81	bushels 4.8	% 65
1930	C2	1,189	568	14.1	62	18.0	90	22.6	100	21.2	100	20.7	98	21.8	103
1931	D	1,019	804	10.3	60	15.9	83	17.1	100	17.9	100	19.0	106	18.4	103
1932	E	1,196	940	14.6	74	17.0	87	19.6	100	17.0	100	16.6	98	17.4	102
1933	C2	1,138	859	14.1	61	19.6	85	23.0	100	22.1	100	23.2	105	24.1	109
1934	C1	1,360	633	8.4	42	16.8	84	20.0	100	17.4	100	17.6	101	18.3	105
1935	C2	1,075	806	4.1	29	10.0	71	14.1	100	12.8	100	14.0	109	13.6	106
1936	C1	691	469	1.7	25	5.2	78	6.7	100	5.3	100	5.1	96	4.7	89
1937	C2	996	462	4.7	44	7.9	74	10.7	100	9.9	100	10.8	109	10.5	106
1938	C1	606	368	10.5	62	16.7	99	16.8	100	12.1	100	11.2	92	11.2	92
1939	C2	1,473	854	10.5	62	16.7	99	16.8	100	12.1	100	11.2	92	11.2	92
Average, 10 crops				8.9	55	13.8	85	16.2	100	14.3	100	14.4	101	14.5	101
Value of Wheat at 3s. 4d. per bushel ...				s. d. 29 8		s. d. 46 0		s. d. 54 0		s. d. 47 8		s. d. 48 0		s. d. 48 4	
Cost of Superphosphate ...				...	...	3 4	...	6 8	...	6 8	...	10 1	...	13 5	...
Net Value of Wheat ...				...	...	42 8	...	47 4	...	41 0	...	37 11	...	34 11	...

* Excluded from average.

Superphosphate applications prior to commencement of the experiment :—
Paddock C1.—1 crop, about 75 lbs. of superphosphate per acre ; Paddock C2.—None ; Paddock D.—1 crop, 75 lbs. of superphosphate per acre ; Paddock E.—None.

TABLE F.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.
Salmon Gums Research Station.—Rate of Superphosphate Experiment—1929-1942.

Year.	Pad-dock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.						High Superphosphate Group.					
		Annual.	May-Oct.	Low Superphosphate Group.			150 lbs. per Acre. (Control)			150 lbs. per Acre. (Control)			225 lbs. per Acre.		
				No Superphosphate.	75 lbs. per Acre.	150 lbs. per Acre.	bushels	%	bushels	%	bushels	%	bushels	%	300 lbs. per Acre.
1929	...	1,173	710	bushels	bushels	bushels	5.0	32	14.4	92	15.6	106	11.3	100	13.2
1930	...	1,623	837	5.0	12.7	13.9	8.2	59	12.7	91	15.6	100	14.1	100	15.2
1931	...	1,669	1,305	8.3	15.6	100	8.3	53	15.6	100	13.9	100	14.8	100	97
1932	...	1,307	1,005	7.3	22.9	95	7.3	30	22.9	95	24.2	100	17.8	100	102
1933	...	1,213	676	5.5	13.0	72	5.5	31	13.0	72	18.0	100	24.0	100	91
1934	...	1,495	682	2.8	9.4	75	2.8	22	9.4	75	12.5	100	19.6	100	115
1935	...	1,146	628	11.4	13.0	85	11.4	75	13.0	85	15.3	100	15.6	100	99
1936	...	1,153	719	3.9	7.2	82	3.9	44	7.2	82	10.8	100	20.3	100	107
1937	...	1,488	695	9.6	13.3	86	9.6	62	13.3	86	15.5	100	10.8	100	104
1938	...	1,829	1,100	9.5	18.4	104	9.5	54	18.4	104	17.7	100	20.5	100	113
1939	...	1,900	803	8.6	14.7	83	8.6	48	14.7	83	17.8	100	23.6	100	102
1940	...	832	522	2.0	2.8	88	2.0	62	2.8	88	3.2	100	20.3	100	109
1941	...	983	676	5.8	11.2	90	5.8	46	11.2	90	12.5	100	5.4	100	116
1942	...	2,066	961	8.8	14.6	85	8.8	52	14.6	85	17.0	100	13.6	100	101
													15.2	100	110
Average, 14 crops	...	...	...	6.9	13.1	88	6.9	47	13.1	88	14.8	100	16.8	100	17.0
Value of Wheat at 3s. 4d. per bushel ...				s. d.	s. d.		23 0		43 8		s. d.		s. d.		s. d.
Cost of Superphosphate ...				...	3 4		...		3 4		6 8		56 0		56 8
Net Value of Wheat ...				23 0	40 4		23 0		40 4		42 8		10 1		13 5
											47 4		45 11		43 3

Superphosphate applications prior to commencement of experiment :—
Paddock A1 and B1.—90 lbs. per acre ; Paddock A3.—290 lbs. per acre.

G.—CONCLUSIONS.

Consideration of the results of all experiments with superphosphate on the research stations, coupled with observations on the growth of bulk crops and trials on a number of private farms leads to the following conclusions:—

1. The most profitable rates of application for the production of wheat for grain in Western Australia—

- (a) For medium and heavy soils: about 1 cwt. of superphosphate per acre.
- (b) For light soils and sandplain country: about 130 lbs. of superphosphate per acre.
- (c) Where land has been well farmed and fertilised for many years these rates could be considerably reduced.

2. The application of superphosphate at seeding is desirable to promote early growth and earlier maturity of the wheat.

3. The residues of former dressings of superphosphate remain in the soil indefinitely and are of great value to succeeding crops.

4. On old, well farmed and previously well fertilised land in the wheatbelt, crop failure due to reduced applications of phosphate need not be feared. Although some reduction in the yield of wheat may result from the application of only 40 lbs. of 18 per cent. superphosphate per acre, it is considered that instances of seriously reduced yields or failure will be due to factors other than the dressing of superphosphate used.

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The Pig Industry.

CARCASS QUALITY.

M. CULLITY, Superintendent of Dairying.

For several years the production of pig meat throughout the Commonwealth has been increasing, and the prices offered by the British Government in its contracts with the Australian Government have been largely responsible for maintaining a tendency to expansion of the industry.

The exports of pig meats from Australia were as follows:—

Year—							tons.
1938-39	..	..	..	..	..	..	13,000
1939-40	..	..	..	..	..	..	24,000
1940-41	..	..	..	..	..	..	33,000

A corresponding increase in production has taken place in Western Australia, where an export trade has been developed:—

EXPORTS OF PIG MEAT—WESTERN AUSTRALIA.						
Year—						lbs.
1935-36	..	..	..	..	..	1,550,285
1936-37	..	..	..	..	..	1,308,864
1937-38	..	..	..	..	..	853,701
1938-39	..	..	..	..	..	1,277,865
1939-40	..	..	..	..	..	5,600,655
1940-41	..	..	..	..	..	13,261,795
1941-42	..	..	..	..	..	10,450,555

However, since the outbreak of war, on a number of occasions it was found necessary to vary requirements for export—sometimes at short notice. This led to considerable dissatisfaction and in Western Australia at least, early in 1941 to a pronounced decline in pig numbers.

The loss of manpower in rural areas throughout Australia later became more serious, and production tended to decline still further on that account. At the same time due to the increased population, composed of evacuees from Malaya and the Indies and of Allied troops, the demand for pig meat became greater than ever previously. It became obvious that adequate extension of production could not be achieved unless the farmer was guaranteed a satisfactory price for a sufficient period.

It is expected that the Commonwealth Government will shortly announce the details of a plan whereby farmers will be given such a guarantee.

In an endeavour to allow the farmer to gain an idea of requirements, State production targets have been set so that the individual States have some knowledge of the extent to which production may be increased with safety.

For Western Australia, this target has been fixed at 10,000 tons, which is slightly higher than the State has ever produced in any one year. Farmers who are in the position to expand their operations are expected to help as far as they are able in meeting the requirements. The expected pig plan will probably include a schedule of prices allowing greater returns for the best quality animals, so that emphasis will be placed on the need for producing carcasses which will meet the requirements of the market, both at home and on export. If the future of the industry is bound up with the export market the production of high quality carcasses becomes still more important as competition will be met from countries where much attention has been given to the improvement of carcase quality. In Western Australia, therefore, the activities of the pig raisers should be directed towards the production of that type of pig which will not only be most profitable, but will also satisfy immediate market requirements and help to establish a reputation for the local pig.

The farmer can do this by using carefully selected breeding animals and by feeding his trade pigs to allow correct development. A real test of a pig can only be made when it is on the hooks in the treatment works, when its make-up of fat and lean meat can be determined. However, in the live pig some characteristics which indicate a greater probability of suitability or of unsuitability are readily discerned.

In an endeavour to demonstrate to pig farmers the type which should be aimed at, the Western Australian Branch of the Australian Stud Pig Breeders' Association some years ago had prepared to their order a chrome-nickel model of an ideal bacon pig (see figure 1) which has been exhibited at agricultural shows and farmers' lectures. In this model the Stud Pig Breeders' Association has expressed the belief of its members that no matter what breed a farmer may elect to use, the importance of producing pigs which will satisfy the commercial bacon requirements should be fully realised.

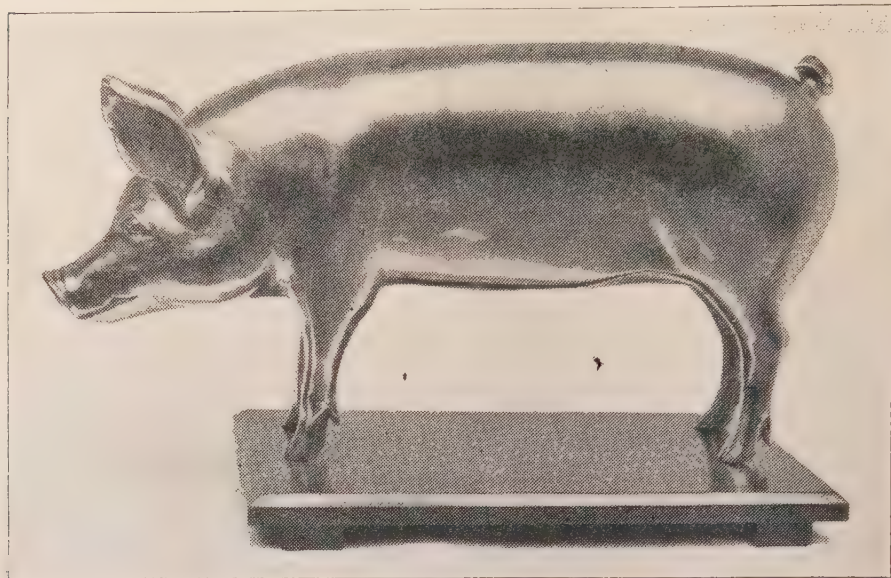


Fig. 1.

Model of standard type of bacon pig prepared by the Western Australian Pig Breeders' Association as a guide to breeders and farmers in the selection of breeding stock for bacon production.

As mentioned earlier, the real test of a pig is when it is on the hooks, when the characteristics of its carcass can be determined, in order to see to what extent it meets commercial requirements. A carcass which will prove suitable for the trade and obtain top prices is one which has maximum meat development and which has an even but not heavy layer of fat. It will be light in those cuts which are low priced (e.g., the shoulders), and well developed in those parts which demand high prices (e.g., the hams).

This type of carcass can only be produced if the breeding animals can transmit the characteristic of lengthy middles to their progeny: the lengthy middle portion allows the development of carcasses which will not be unduly fat while they supply a large amount of lean meat.

A pig which is long for its weight will usually prove to be less fat than one which is short at the same weight. The more lengthy pig, in addition, will give a greater proportion of back cuts than belly cuts, the latter being cheaper than the former.

The back of the pig should be slightly arched from head to tail. The shoulders must not be heavy, or coarse, but light, smooth, and tapering slightly or rounded, rather than broad and flat; they are a relatively low priced part and when they form a smaller proportion of the whole carcass, it is considered desirable.

The pig which is likely to yield an unsuitable carcass is one which is short and which, therefore, at bacon weights is deep and wide. On slaughter such a pig will show a very thick layer of fat on the outside of the muscular parts. The fore-quarter will probably be heavy and the whole carcass one from which it is impossible to get cuts which will satisfy the buyers in the retail shops.

The pig which at time of slaughter is lengthy, not excessively deep, and has a clear cut underline will usually meet these requirements.

The difference between suitable and unsuitable sides is illustrated in Fig. 2 with two sides of equal weight.



Fig. 2.

Short undesirable side with too thick a layer of fat along the back compared to a lengthy side. Both sides are the same weight. Ministry of Agriculture Report on Empire Pork and Bacon Trades, 1928.)

Between the vertical processes of the backbone and the ribs runs a muscle lengthwise along the back of the pigs; this forms the eye of the meat in the cut through the loin and in the bacon rasher. To provide a seating for this muscle and to allow adequate room for its development, the ribs must be well sprung and not slope rapidly downwards from the backbone. They, however, should not be too rounded, but in the finished pig there should appear to be a distinct break from back to side. The backfat should be even without any pronounced thickening over the shoulder and should measure not more than $1\frac{1}{2}$ inches.

A thick streak (over $1\frac{1}{2}$ inches) with plenty of lean meat is desirable. Thick bellies are frequently produced by over-fattening. These are deficient in meat and

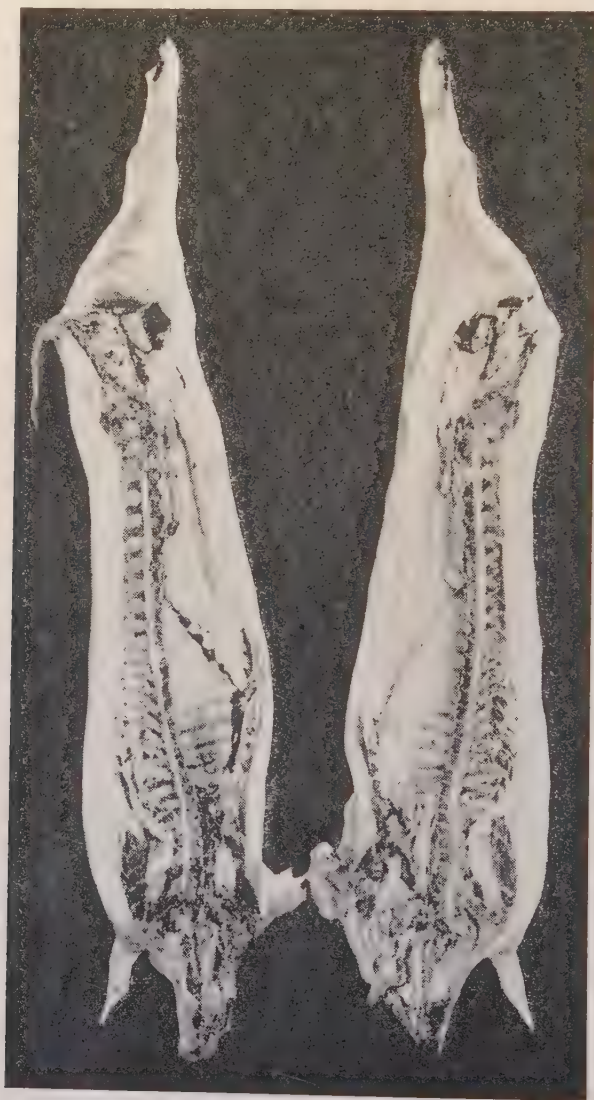


Fig. 3.
A heavyweight overfat carcass.

do not fill the requirement of a thick streak which is thick because of the muscle development rather than fattening.

The combination of a thick meaty streak with a well developed "eye" muscle and thin backfat gives the sort of pig meat demanded by the public.

The hams should be well filled out with lean meat extending down to the hocks. The space between the legs when U rather than V shaped suggests better development.

The *fat in the carcass* should be firm—a soft oily fat is objectionable from the point of view of the purchaser. The firmness is influenced more by feed than by breed, and by the rapidity of growth, a fast growing pig will usually show firmer fat than a slow growing one. This fact again is probably most frequently due to the differences in the amount and kind of feed which influence the rate of growth.

The character of a carcass, however, is not regulated solely by the breed and type of the parents. Feeding affects the size, muscle or lean meat development and the amount of fat and accordingly it is possible to feed pigs of similar inherited type so that they will appear quite dissimilar at equal bacon weights. The influence of feeding on experimental pigs at the Muresk Agricultural College is shown elsewhere in this Journal.

A study of the plates, particularly 7 and 8, will show difference in growth between pigs of same litters receiving different mixtures, while the sides and loins of the pigs representing groups 1 and 2 show pronounced differences in the development of the lean meat and accumulations of fat.

The classic experiments of McMeekan and Hammond have shown that the proportions of fat and lean meat in the carcass of the pig can be varied very considerably by adjusting the quantity and composition of rations.

The importance of providing the young and growing pig with a full properly balanced ration in order to allow full development of the skeleton and of the muscular system was demonstrated. The fact that the bone and muscle development takes place most rapidly in the early months when sufficient feed is provided and that fat deposition becomes rapid only after bone and muscle growth has slowed down, proves the most useful guide to farmers in growing pigs of the right type. Full feeding in the early stages with some restriction in the quantity fed when the pig is four to five months of age, is the method which will prove satisfactory. The free unrestricted form of feeding leads to the production of a pig which reaches bacon weight before it has finished making full skeletal growth and is accordingly shorter and fatter than desirable.

Feeding a restricted quantity in the early months and then speeding up to "top off" accentuates the condition described above. Bone and muscle growth is restrained and as the pig reaches maturity additional feed is given which results in a short fat pig.

The expected new system of controlling purchase of pig meat will, because of the differences in price to be paid according to the grade of the carcass, tend to encourage farmers to forward the type of pig which will be classified as top quality. To do this proper selection of breeding stock is the first step, as while pigs of good inherent type may be spoilt by improper feeding, pigs of poor inherent type cannot be built into good pigs by feeding.

Having good stock to begin with, feeding a properly balanced ration, so as to encourage bone and muscle development will provide marketable pigs of top quality.

It is not sufficient for the farmer to produce pigs which will meet the requirements as described, but in addition care is needed to ensure that the animals will reach the bacon factory in an unblemished condition.

A visitor to any treatment works will be impressed by the damage to carcasses which occurs through rough handling. The use of dogs, kicking, prodding with sticks or other similar methods of moving pigs, results in bruises which mar the carcass. The bruised flesh is useless and has to be removed. (See plate 4.)

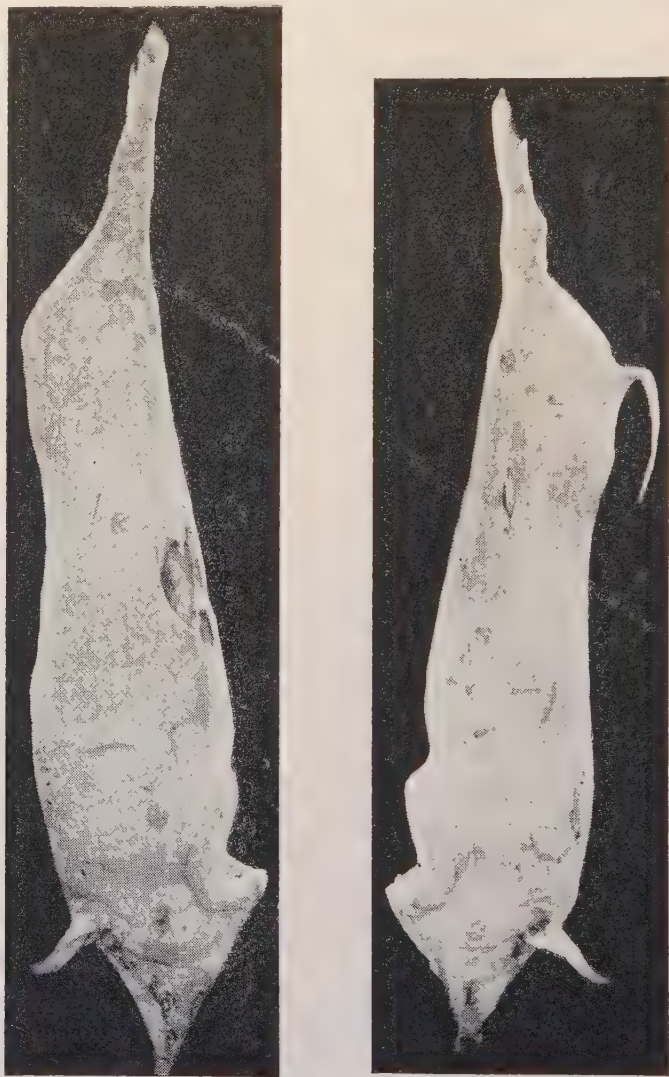


Fig. 4.

Carcasses blemished with bruises and with scoring of the skin.

Many blemishes which are only skin deep, but nevertheless spoil the "finish" are caused in a similar way, as well as by the use of barb wire fences, badly constructed pens and loading appliances. Fighting among the pigs also causes marks which persist after slaughter.

The Cabbage Butterfly.

(*Pieris rapae* L.)

A RECENTLY INTRODUCED PEST.

C. F. H. JENKINS, M.A., Government Entomologist.

The Cabbage Butterfly is a well known pest of cabbages and cauliflowers in many parts of the world. Its native home is Europe but in 1858 it was accidentally introduced into North America, and since then it has spread to many countries, including Hawaii, New Zealand, and Australia. The first record for Australia came from Melbourne in 1939, and since then its spread has been rapid, for by the end of 1940 it had reached Tasmania, New South Wales, and South Australia.

In an effort to prevent the pest reaching this State regulations were early gazetted prohibiting cabbage and other plants likely to harbour the insect being sent to Western Australia from affected areas. Unfortunately these measures proved of but little avail, as early in January, 1943, the first Cabbage Butterfly was caught at Bassendean in a backyard vegetable garden.

Investigation further afield soon showed that the pest had reached other suburban districts, including Midland Junction and Cannington, as well as the Hills localities of Parkerville and Mundaring.

How the pest reached Western Australia it is difficult to say but there seems little doubt that despite quarantine regulations infested vegetable material has entered the State.

An example such as this shows how easily new pests may be introduced into a country and how important it is for all individuals to co-operate in helping to make quarantine measures as effective as possible.



Fig. 1.

Cabbage Butterfly. (Upper) female; (lower) male.

The Cabbage Butterfly must not be confused with the Cabbage Moth. The latter is a tiny greyish insect, the small green caterpillars of which are well known to all cabbage and cauliflower growers. The Cabbage Butterfly, on the other hand, is a large conspicuous butterfly which has only just established itself in Western Australia.

Butterfly.

The butterfly is white marked with black or very dark brown near the tips of the forewings, and has a wing spread of about two inches. There is some variation in size and the males are usually a little smaller than the females. In addition, the female has two black spots on each forewing, whereas the male has only one spot. The hind wings in both sexes have a single black spot near the front margin and are pale yellow on the underside.

This insect should not easily be confused with any native butterflies in this State, for the only common white butterfly in the South-West is rather larger in size, has more black markings, and shows some conspicuous red spots when the wings are held erect over the back.

Egg.

The pale yellow eggs of the cabbage butterfly are bullet shaped and just visible to the naked eye. Under a lens it will be noticed that they are ribbed and sculptured in a characteristic manner.

Caterpillars.

The caterpillars are velvety green in colour with a faint yellowish line running down the centre of the back. They measure about $1\frac{1}{4}$ inches in length when full grown.

Chrysalis.

The chrysalids or pupae measure about one inch in length and are usually greenish or greenish yellow in colour, but they may vary considerably according to the background.

HABITS AND LIFE HISTORY.

Accurate details concerning the life history under local conditions are of course not yet available, but experience in other States may be taken as a satisfactory guide.

The butterflies may be expected to appear early in the spring, when they will fly over vegetable gardens looking for suitable food plants. A single female may lay up to 400 eggs which are deposited singly on the leaves, usually on the under surface near the edge.

The egg stage lasts about a week, the time varying according to weather conditions. The caterpillar stage may last about two to three weeks and the chrysalis or pupal stage about a week or ten days, so that from the laying of the egg to the appearance of the butterfly may occupy a month to six weeks. Breeding will continue during favourable weather conditions, and so several generations can occur annually.

When fully fed the caterpillars may pupate on the food plant or wander away to a neighbouring fence or tree. Here they will secure themselves to a suitable support by a silken loop and undergo the change into the winged adult.



Fig. 2.

A. Caterpillar and B. pupa or chrysalis of Cabbage Butterfly on leaf.

When very small it may be difficult to distinguish the green caterpillars of the Cabbage Butterfly from the Cabbage Moth, but the moth caterpillar, when touched or disturbed usually wriggles and squirms very actively, often dropping and suspending itself from a leaf by a silken thread, whereas the butterfly caterpillar is usually rather sluggish.

Host Plants.

The caterpillar has been recorded as feeding upon lettuces and all cruciferous plants such as cabbages, cauliflowers, turnips, kale, radish, stocks, etc., but cabbages and cauliflowers are the favourite food plants.

Economic Importance and Type of Injury.

The Cabbage Butterfly is a very serious pest in European countries; whether it will prove to be equally serious in this State it is yet too early to say. There is no doubt, however, that if neglected it will cause serious damage to various vegetable crops.



Fig. 3.
Cabbage injured by caterpillars of the Cabbage Butterfly.
Note caterpillar feeding on heart.

The injury caused is very similar to that done by the Cabbage Moth caterpillar, excepting that as the butterfly caterpillar is much larger than that of the moth the injury it causes is more gross. The leaves of food plants may very soon be holed and even skeletonised if control measures are not adopted.

CONTROL.

Fortunately the routine control measures adopted by most growers against the Cabbage Moth should be effective against the Cabbage Butterfly. It should be realised, however, that where this new pest is established the need for exercising these control measures will be even more drastic.

A careful watch should be kept for the first signs of Cabbage Butterfly injury, so that action can be taken early. Young plants can be sprayed or dusted with arsenicals without danger, but the use of arsenate of lead should be discontinued at least six weeks before the plants are ready to cut. If thorough treatments are given at the early stages it is often possible to so reduce the pest that mature vegetables can be easily protected by other measures.

Arsenical Dusts and Sprays.

A dust consisting of equal parts of arsenate of lead and slaked lime, kaolin, or some other inert carrier will give the best control. The mixture may be applied

either with a dust gun or shaken on through the meshes of a bag or some other suitable fabric.

When arsenate of lead sprays are used the mixture should be applied at the rate of $\frac{1}{2}$ ounce of powdered arsenate of lead, or 1 oz. of paste to one gallon of water. The mixture must be kept thoroughly agitated while in use, as the arsenate of lead is not soluble and will gradually settle to the bottom. The addition to every gallon of about 1 oz. of flour mixed to a paste (or a proprietary spreader) will help the spray to adhere to the foliage.

Treatments should be repeated about every ten days or a fortnight according to the severity of the infestation. But it cannot be too strongly emphasised that one treatment given to check an incipient outbreak is worth half a dozen given after the pest has gained a firm hold.

Non-Poisonous and Nicotine Dusts and Sprays.

If it is found necessary to treat hearting cabbages or cauliflowers, a non-poisonous dust such as derris 1 part and kaolin 8 parts, can be used. The mixing of derris with slaked lime is not recommended. Various proprietary lines containing derris are available. Derris is somewhat slower in its action than arsenate of lead, but has been definitely proved effective against the cabbage butterfly caterpillar.

Dual-purpose Dusts.

Nicotine dusts or sprays will also be found effective and may be prepared as follows:—

- (i) Nicotine sulphate or Black Leaf 40, $1\frac{1}{2}$ teaspoonfuls; soap, 1 oz.; water, 1 gallon.
- (ii) Nicotine sulphate or Black Leaf 40, 1 part; slaked lime, 16 parts.

Where aphids as well as caterpillars have to be dealt with the following mixtures make useful dual purpose dusts:

1. Arsenate of lead, 8 parts; slaked lime, 8 parts; nicotine sulphate, 1 part.

If nicotine sulphate is not available the following is suggested:

2. Arsenate of lead, 3 parts; slaked lime, 1 part; tobacco dust, 2 parts.

Other useful dusts are:

3. Derris, 2 parts; kaolin or talc, 14 parts; nicotine sulphate, 1 part.
4. Derris, 1 part; slaked lime $1\frac{1}{2}$ parts; sulphur, $1\frac{1}{2}$ parts; tobacco dust, $1\frac{1}{2}$ parts.

Where only small quantities of dust have to be mixed, this can usually be done in a tin. The nicotine sulphate should be sprinkled over the dust and if possible a close-fitting lid should be placed on the tin while it is thoroughly shaken up after the initial stirring. One or two small stones in the tin will assist the mixing.

Where large quantities of material are required a barrel on a stand and axle and revolved like a churn is advisable. Again the addition of a few stones will help the mixing.

Cultural Control.

All old infested plants should be destroyed and as far as possible seedlings should not be planted close to areas previously laid down to closely related crops.

When cutting cabbages, etc., the whole plant should be pulled up so that the butt is not left to act as a harbour for pests.

The destruction of weeds of all kinds should be carried out as a routine practice, no matter what pest it is desired to control.

Biological Control.

Very favourable results are being obtained in New Zealand from the use of a wasp parasite (*Pterolamius puparum*) introduced from Europe. The wasp attacks the pupa of the host and prevents the development of the adult butterfly.

IMPORTANT!

As the Cabbage Butterfly apparently has a limited distribution up to the present time, growers are asked to keep a constant watch for the pest and to report outbreaks immediately to the Department of Agriculture.

Copper Deficiency in Sheep.

H. W. BENNETTS, D.V.Sc.

It is now known that large and widely separated areas of this State, particularly in the south, are deficient in copper. The degree to which various types of country are affected varies considerably; in the more deficient areas stock constantly show some signs, whereas in less affected areas evidences of deficiency may be apparent in certain seasons only. Seasonal conditions, in fact, exert a marked influence throughout; in general, stock are most markedly affected during the winter months and in good years when there is a flush of feed.

Sheep appear to be particularly susceptible to the deficiency and the state of the flock, especially the wool quality, is a good index of the general copper status of the areas on which the sheep are depastured.

SIGNS OF COPPER DEFICIENCY.

In adult sheep these are three:—"Stringy wool," anaemia and excessive scouring.

"Stringy wool" occurs even when pastures are deficient to such a mild degree that all other signs are indefinite or absent. In fact the absence of this wool defect in a clip, predominantly of the merino type, can be taken as reliable evidence that stock are receiving adequate copper from the pastures, provided, of course, that copper is not being supplied through bluestone worm drenches, etc.

The characteristics of "stringy wool," sometimes referred to also as "slippery" or "straight steely" wool, are loss of crimp and straight, glassy or silky appearance; the fleece lacks "bulkiness." The defect is much more noticeable in merino than British breed types.

The anaemia and excessive scouring, associated with a fairly severe degree of copper deficiency, occur particularly in the breeding ewes and are noted, generally, only during the winter months. Obviously both anaemia and scouring may

be due to many causes other than copper deficiency and in the absence of the characteristic sign, "stringy wool," they cannot be taken as an indication of deficiency.

In lambs the characteristic sign is ataxia, popularly and quite wrongly known as "rickets." This disease, definitely due to copper deficiency, affects lambs from birth to when about four months old; very rarely older animals are affected. Typically there is some check in growth followed by a loss of control of the hind legs which at first is noted during driving, when movement becomes progressively more difficult. Finally the hind quarters sway ("sway back") and the affected lamb falls over and is only able to proceed again after resting. The condition gets progressively worse until in the course of days or weeks the lamb can travel only short distances or not at all.

The characteristic inco-ordinated gait (ataxia) results from degeneration of the nervous system and should not be confused with the stiffness and lameness seen in arthritis, an infectious disease.

More rarely copper deficient lambs are born dead, or are affected at birth or when a few days old with a rapidly fatal disease in which there are signs of brain involvement. In general the earlier the lamb is affected the more rapid and fatal is the course of the disease. Usually lambs do not show signs until about four to eight weeks old; these may survive for weeks and although the majority die others may grow to maturity. Some abnormality of gait, however, almost always persists.

The numbers of lambs affected and the course taken by the disease is related to the degree of copper deficiency and may vary considerably from year to year, particularly in areas not severely deficient. *It has been shown quite definitely that a degree of deficiency insufficient to cause ataxia may, however, retard the growth and development of lambs to quite a marked extent.*

THE CONTROL OF COPPER DEFICIENCY.

Measures to prevent, or to arrest the effects of copper deficiency in the flock may take the form of:—

1. Direct administration of copper supplement in the form of licks or drenches.
2. Indirect administration by increasing the copper content of pastures to satisfactory levels by topdressing with copper compounds.

The former method of supplementation is very cheap. It is recommended principally where it is uneconomic to topdress any considerable area, e.g., where the country is predominantly of a light type carrying unimproved pasture. Where, however, good quality pasture species are being encouraged (N.B., subterranean clover which has a high copper requirement) or where cereal crops show evidences of copper deficiency, the extra cost of topdressing will be more than compensated for by the resultant improved quality and/or quantity of the herbage. All sheep depastured thereon must receive a regular and adequate supply of copper whereas this cannot be guaranteed when copper supplements are fed under practical farming conditions. In this connection it has been shown by experiment that sheep receiving small amounts of copper at frequent intervals do better than those taking it irregularly, even in large doses. The choice of methods, however, will depend largely on economic and practical considerations.

It should be noted that copper is a poison and that excessive supplementation may result in a disease, characterised by redwater and jaundice, and which is fre-

quently fatal. It is very unlikely that topdressing could raise the copper content of herbage to dangerous levels, but the *uncontrolled* use of salt-copper licks, particularly on copper-dressed country, should not be permitted.

Licks.

A bluestone-salt lick is recommended. The strength used depends on the amount of lick consumed by the sheep.

In general the following has been found satisfactory:—Bluestone $\frac{1}{4}$ lb.; salt 100 lbs.

Consumption of this lick at the rate of about 2 oz. per sheep per week will give an adequate copper supplement. More than double this amount can be taken with complete safety. If after a few weeks, the intake is considerably in excess of or is below the amount recommended, the strength of the lick should be adjusted proportionally.

To mix the lick, dissolve the required amount of bluestone in a small quantity of water in a non-metal container. Sprinkle solution over the salt and then mix in until colour is uniform, indicating that the bluestone is evenly distributed throughout; a spade is useful for mixing.

Lick should be fed throughout the year for the best results, but particularly during the in-lamb period and throughout the winter months. During the wet season the lick must be protected from the weather, otherwise rain will wash out a considerable proportion of the bluestone which is readily dissolved away from the outside of the grains of salt.

The lick is taken well by sheep in the more inland copper deficient areas.

Drenches.

Drenching has only a limited usefulness. Its main value would be for the arresting of ataxia; lambs showing early signs of the disease may be reared satisfactorily if given a bluestone drench daily or at least three times a week. For this purpose first make a *strong* solution by dissolving 1 oz. bluestone in $2\frac{1}{2}$ pints water. To make a *dilute* solution for drenching, take one fluid ounce (two table-spoonsful) of the strong solution and add water to make up to one pint. Give one fluid ounce of the *dilute* solution daily or two fluid ounces three times a week. Do not use metal containers for making up or storing solutions.

In cases where for some reason*, it is impracticable to supplement the diet of the in-lamb ewe in either of the other two ways drenching may enable it to build up adequate reserves of copper to prevent the occurrence of ataxia in the lamb born subsequently. For this purpose the full "worm" dose of bluestone may be administered at monthly or more frequent intervals. This procedure naturally, is less satisfactory than the recommended methods.

Topdressing with Copper.

The copper content of mixed pastures, in deficient areas, can be raised to normal values following topdressing with copper compounds mixed with superphosphate.† Sheep grazed on such pastures receive adequate copper and in general

* Licks do not appear to be taken readily on "coasty" country, particularly where large unsubdivided areas are grazed. Under these conditions drenching with copper (and cobalt) supplements has given satisfactory results. Bennetts, H. W., *Journal Department of Agriculture, W.A.*, 17 : 41, 1942.

† Cereals which are poor collectors of copper differ in this respect. However, herbage growing with the cereal, and subsequently, will have an increased copper content and thus supplement the intake of sheep grazing the cropped areas.

do very well. This is the ideal method of supplementation provided it is economically justifiable, i.e., if increased pasture and cereal yields warrant the extra expenditure.

For topdressing either bluestone or oxidised copper ore mixed with superphosphate, is recommended. The initial dressing should be equivalent to 5-10 lbs. bluestone to the acre. This is very probably effective for more than one season, but until further information is available it is recommended that light dressings equivalent to 2 lbs. bluestone per acre be applied each subsequent season.

THE DISTRIBUTION OF COPPER DEFICIENCY.

We have ample evidence that "stringy" wool, and to a less extent ataxia, will occur in any of the areas known to be copper deficient, and in fact the occurrence of "stringy" wool has been used to indicate areas which are incipiently deficient.

In a number of districts, where copper deficiency diseases of animals were first recognised and studied in 1936, large tracts of land are deficient so that stock depastured almost anywhere throughout showed definite evidences of deficiency.

In other parts of the State, however, notably in the wheat belt, only certain types of land are deficient so that individual properties may be made up of a variable proportion of deficient and healthy country. Whether stock show signs of deficiency would depend primarily upon the class of country to which they have had most access during that particular year.

It should be noted that experience in the affected areas clearly shows that the evidences of copper deficiency become progressively more manifest with time and with the increased rate of stocking which follows clearing of the country, the elimination of natural scrub, and the development of improved pastures. In effect country which in its unimproved state carried stock satisfactorily may, following development, no longer do so.

Copper deficiency has been shown to be widespread through the following areas:—

(a) Gingin and Dandarragan.

(b) The South-West—the jarrah, redgum country around Mt. Barker and in the Busselton, Margaret River and Northcliffe districts is to a very great extent severely deficient.

(c) "Coasty" country. The wind-blown sand dune type appears to be quite generally deficient in copper, evidence being available from as far north as Broome to Hopetoun on the south coast. (Generally there is a complicating deficiency of cobalt also which gives rise to the wasting characteristic of "coast disease"). Semi-coastal country further inland is frequently copper deficient also (e.g., around Albany).

Areas in which copper deficiency is irregularly distributed instead of generally.

These have not been studied so completely yet, but it is clearly evident that such areas are widespread throughout the State. In this connection "stringy wool" has been recorded as far inland as Kukerin and Kondinin in the south and Dalwallinu and Mukinbudin in the north.

(a) in the South-West. Forest country, other than areas mentioned above, e.g., Denmark, Manjimup, Pemberton.

(b) Great Southern and Wheat Belt areas. "Stringy wool" has been reported from a large number of widely distributed properties on some of which ataxia occasionally occurs also, e.g., at Kwolyin, Corrigin, Bulyee and Tambellup.

In some localities only occasional properties are affected, in others as in the vicinity of Corrigin rather large areas are affected.

Investigations have indicated that the types of country likely to be affected are light sandy (or sandy, gravelly) soils carrying predominantly white gum, tamma, wodgil, or white gum, associated with stunted jam and casuarina, although these vegetation associations do not necessarily indicate copper deficiency. It appears quite evident, however, that heavier forest country carrying salmon gum or york gum is quite healthy and where sheep have adequate access to this, as well as to the lighter types, they are able to obtain sufficient supplies of copper for all bodily needs.

SUMMARY.

1. The characteristic signs of copper deficiency in sheep are "stringy wool" and ataxia; the former may indicate only a mild degree, the latter is evidence of a more severe degree of deficiency.

Other signs are anaemia and excessive scouring of sheep and slow growth of lambs.

2. These can all be prevented by the use of copper supplements which may be given as a lick (a drench) or by topdressing with copper compounds mixed with superphosphate.

3. Copper deficient areas are widespread throughout the State. Some of these areas are markedly and rather generally affected so that stock show evidences of deficiency on most properties. In other parts of the State (N.B., the Wheat Belt) only certain types of country appear to be deficient and both deficient and healthy country may occur on individual properties within these areas. The presence or absence of signs of copper deficiency in sheep carried depends primarily upon what types are grazed.



"Stringy" wool from Mount Barker.
[Photo. Govt. Print.]



Healthy Merino Wool.
[Photo Govt. Print.]

Wilt Diseases of Tomatoes.

W. P. CASS SMITH, Plant Pathologist.

The term "tomato wilt" is very confusing to tomato growers in general, and to inexperienced home gardeners in particular, for they naturally assume that it refers to a single disease. Letters are frequently received from worried growers telling of the losses caused by "tomato wilt" and asking for the best methods of treatment. However, unless diseased specimens are also forwarded or the symptoms carefully described, it is impossible to advise them definitely, for in Western Australia symptoms of this general type may be produced by three entirely different diseases, each of which requires different treatment. Two of these, namely, *Fusarium* and Bacterial wilt of tomatoes, are caused respectively by fungal and bacterial parasites, while the third, known as spotted or bronzy wilt, is caused by a virus.

Fusarium and Bacterial wilt may both be transmitted with the seed or contaminated soil, whereas spotted or bronzy wilt is not disseminated by either of these means.

SPOTTED WILT OF TOMATOES.

Spotted wilt was first recorded in this State in 1923 in the metropolitan area. Since then it has spread to many other parts, including the main tomato growing areas. In commercial crops losses vary considerably from year to year, but on the average it is easily the most serious disease of tomatoes, annually affecting thousands of plants.

In the metropolitan area it is always a serious menace, so much so, that the successful cultivation of tomatoes in home gardens is now most precarious.

Symptoms.

The disease may attack plants at any stage of growth, and one of its most striking features is the suddenness with which it develops. Tomatoes which appear vigorous and healthy one day may on the next show a wilting of the topmost leaves which tend to curl downwards and inwards. Shining bronze or copper-coloured spots also appear on the youngest foliage (Plate 1) and within a few days the spotted leaves shrivel and die. Occasionally tomato plants are killed outright by the disease but this occurs most frequently when young seedlings become infected. Usually the plant is not killed but growth is arrested and the dwarfed plants may struggle along unthrifily for months.

The fruit of affected plants may ripen normally, especially when it is well developed prior to infection; on the other hand, it often shows yellowish markings which range from an irregular mottle to very distinct concentric circles, and such fruit is watery and of poor quality (Plate 2). Spotted wilt is caused by an infective principle or virus which is transmitted from diseased to healthy plants by two species of thrips—the onion thrips and the black carnation thrips. If these insects while still in the larval stage suck the sap of a plant affected with spotted wilt, they become infected with the virus and to the end of their lives they are capable of transmitting it to healthy tomatoes or other susceptible host plants. After infection the virus multiplies rapidly in the living cells of the host, but only after several days have elapsed, during which the virus spreads throughout the plant, do symptoms of the disease appear. It will be apparent therefore, that spotted wilt cannot be checked by cutting off affected young tomato foliage, or, that plants showing definite symptoms are the only ones infected with the virus.



Plate 1.

Tomato leaf showing symptoms of the spotted or bronzy wilt virus. The disease first becomes evident on the upper surfaces of the youngest foliage where shining bronze or copper coloured spots appear. The spots may be so numerous that a characteristic sheen is imparted to affected leaflets.

“Wilt-Resistant” Varieties.

From time to time varieties are offered for sale, with the claim that they are “wilt-proof” or “wilt-resistant” and in order to avoid a repetition of past troubles, growers are sometimes persuaded to purchase seed or seedlings. Many of these growers have since bitterly complained that these claims were quite unjustified, for the varieties proved to be susceptible to spotted wilt. It cannot be too strongly emphasised that resistant varieties are only available in the case of *Fusarium* wilt, and none of the commercial varieties grown in this State have shown resistance to spotted wilt. Growers who purchase seed or seedlings of these so-called “wilt-resistant” varieties should insist that the specific disease for which resistance is claimed is also named.

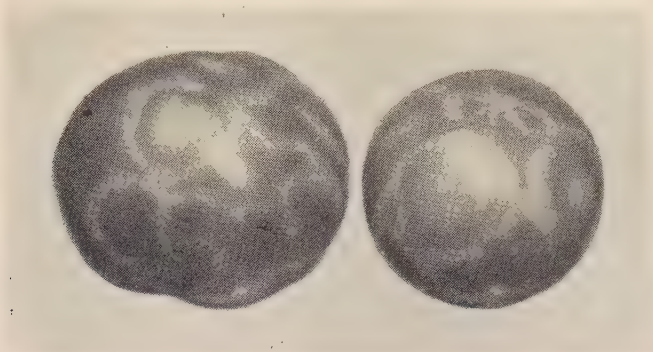


Plate 2.
Yellowish concentric markings on ripe tomatoes affected with spotted wilt.

Host Range.

The control of tomato spotted wilt is complicated by the fact that many flower garden plants and common weeds are also affected by the disease. By harbouring infected thrips these plants perpetuate spotted wilt and increase the sources from which infection may spread to tomatoes.

According to Smith (1937*), the disease has been recorded on more than 100 species of plants belonging to 19 different families, and this number is continually being added to. Susceptible plants listed by Smith include:—

Ornamentals.—Petunia, delphinium, iceland-poppy, begonia, lupin, aster, nasturtium, dahlia, zinnia, chrysanthemum, anemone, ranunculus, salpiglossis.

Common Weeds.—Plantain, black nightshade, dock, sorrel, milk thistle, arum-lily.

Naturally occurring symptoms of spotted wilt have been observed locally on most of the abovementioned plants and in addition the common capeweed is suspected of being an important weed host.

The symptoms shown by these alternate host plants may vary widely from those developing on the tomato, and in consequence the disease is seldom recognised as spotted wilt by the grower, although he is often well aware that the plants are unhealthy (Plates 3 and 4). Common symptoms, often indicative of spotted wilt, include distortion, spotting or partial killing of leaves and floral parts, together with a general stunting of growth.

Control Considerations.

From what has been said it will be appreciated that the complete control of spotted wilt of tomatoes depends on the elimination of insect carriers combined with the eradication of diseased plants. In practice this has proved to be an impossible task for, except in glass-houses, the common contact insecticides have only partially controlled the thrip carriers, while the varied symptoms shown by a vast and seemingly never-ending number of widespread host plants preclude the possibility of destroying all diseased plants. In home gardens, in the metropolitan area or large towns, losses from spotted wilt are relatively much greater than in commercial plantings, because the growing of tomatoes in close proximity to susceptible ornamentals cannot be avoided.

*Kenneth M. Smith. Text book of Plant Virus Diseases, 1937.

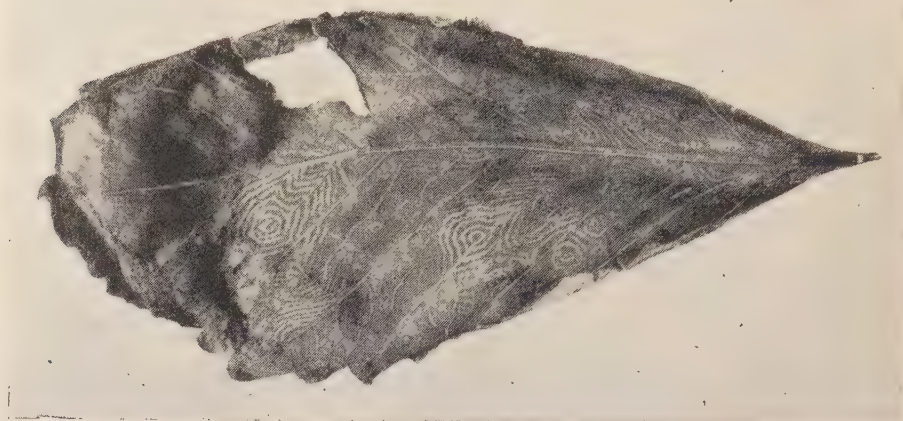


Plate 3.

Dahlia leaf showing spider web-like, concentric markings of spotted wilt. Dahlias are very commonly affected with the disease, and are an important host, for through the medium of infected tubers the disease is perpetuated year after year, and transported to new areas.



Plate 4.

On left, two zinnia leaves showing symptoms of spotted wilt, produced by mechanical inoculation.
On right healthy (control) leaves.

[After Bald & Samuel, C.S.I.R., Bull. 54.]

Under commercial conditions this difficulty seldom arises, and by paying particular attention to "sanitation practices" the spread of the disease can be limited in most years.

In commercial plantings the protection of young plants in seed-beds is of the utmost importance, for rapid transmission of the disease may occur at this stage unless adequate precautions are taken. This was well illustrated in the Geraldton area last year, when a grower with insufficient seedlings of his own

raising, obtained surplus plants of the same variety from a neighbour. Shortly after planting out, a high proportion of the introduced seedlings developed spotted wilt, whereas the grower's own plants were quite healthy.

Outbreaks of spotted wilt have also been noticed following the use of sewage sludge. This manure often contains innumerable tomato seeds, and unless the seedlings are eradicated at an early stage they harbour infected thrips and serve to "breed up" the disease.

Recently it has been announced both from South Africa and New South Wales that a tartar emetic foliage bait has given promising control of thrips, thereby reducing the incidence of spotted wilt considerably. Unfortunately this material is not available at present, but efforts are being made to import it. The formula recommended is tartar emetic 2 ozs., brown sugar 4 ozs., water 4 gallons. The bait is applied twice a week to the plants in seed-beds, and once or twice a week, later, when planted out; for seed-bed purposes the amount of tartar emetic may be reduced by half in the above formula.

It is possible that the use of this bait will revolutionise methods of spotted wilt control, but until this can be proved under local conditions, strict attention should be paid to the following points which will assist, at least to some extent, in checking the disease:—

Control Measures for Commercial Growers.

1. In country districts where the disease has not yet been noticed, always grow tomatoes and common garden-flowers from seed. Tomato or ornamental seedlings obtained from the metropolitan area or elsewhere where the disease exists may introduce spotted wilt.

2. Locate seed-beds in well cultivated ground well away from headlands or other places harbouring weeds. If both early and main crops are to be grown select well separated sites for each seed-bed.

3. Apply contact insecticides frequently to the young seedlings. Prepared white spraying oil 1-80 plus nicotine sulphate added at the rate of one teaspoonful per gallon of the oil spray is useful for this purpose, and both may be combined with a routine Bordeaux-mixture spray.

4. Carefully inspect the seed-beds at frequent intervals and remove and destroy plants showing symptoms of the disease.

5. Plant out on to land which has been well worked to destroy weeds and endeavour to keep down weed growth during the growing season.

6. After planting out include contact insecticides in sprays, or dusts, applied to control fungal diseases or chewing insects, and remove and destroy diseased plants as soon as noticed.

Control Measures for Home Gardeners.

1. As (1) under measures for commercial growers.

2. If seedlings are purchased, carefully examine and select plants free from suspicious looking symptoms.

3. If growing from seed, sow directly in the positions where the plants will remain. Several seeds slightly separated may be sown in each position; this will provide transplants if germination is faulty and will allow any diseased young plants to be removed and destroyed, without leaving "misses." Ultimately, when the plants are well established, thin out, leaving the most vigorous plant in each case.

4. Observations over a number of years indicate that plantings made from mid-December to mid-January, are usually less affected by spotted wilt than spring plantings.

5. Grow the plants in well-cultivated soil kept free of weeds and as far away as possible from flowers.

6. During growth keep the plants well dusted with a mixture containing 10 parts basic copper carbonate, 40 parts flowers of sulphur, and 50 parts air slaked lime. This will largely control fungal leaf spotting diseases and may give some control of thrips also.

7. Remove and destroy diseased young plants immediately, as they will remain unthrifty even if they survive. If spotted wilt develops after the fruit has formed destruction of diseased plants is of doubtful value especially when plants are few in number. In mid-summer plantings late affected plants frequently mature fruit (although this may be of inferior quality) when soil conditions are favourable.

FUSARIUM WILT OF TOMATOES.

Fusarium wilt of tomatoes is a fungus disease, which is present in practically all countries where tomatoes are grown. In this State the disease has been recorded from all the main tomato growing areas, and it ranks second in importance to spotted wilt; the economic losses caused have so far been far less serious, however, than those brought about by the latter disease.

Symptoms.

Usually the first visible symptom of Fusarium wilt is the yellowing of the lower leaves. These gradually turn brown and finally wither. At first these symptoms may be confined to a branch or two on one side of the plant only, but gradually the disease extends, killing the leaves successively from the base upwards, until the whole plant wilts and dies. (Plate 1.)



Plate 1.
Fusarium wilt. Diseased plant at right, healthy plant at left.

[After Humbert.]

If a branch on which the leaves have withered is cut open lengthways or pulled off at the fork in the stem, a brown discolouration of the water-conducting tissues can be noticed. (Plate 2.)



Plate 2.

Fusarium wilt. Stem portion split lengthways to show the brown discolouration of the water conducting tissues.

[After Bohn & Tucker.]

The disease may attack plants at any stage of growth, but it commonly appears first just as the fruits are ripening.

Cause of the Disease.

The fungus causing this disease (*Fusarium lycopersici* Sacc.) when once introduced into the soil may live on dead organic matter for many years. When susceptible tomato plants are grown the fungus may attack the roots especially through slight injuries and grow through them into the main stem. Here it develops mainly in the large water-conducting strands, and gradually spreads through them from the base towards the top of the plant.

As a result the upward flow of sap containing dissolved food materials is restricted so that finally the plant becomes unthrifty and wilts.

During wet weather plants killed by fusarium wilt frequently develop pink layers on their surfaces which consist of innumerable spores (fungal seeds) of the fungus. Unless such plants are removed the spores are widely disseminated to other parts of the field.

The disease is encouraged by relatively high temperatures, the optimum being about 85 deg. F., and under local conditions it is chiefly troublesome during the late spring and summer months.

There are several ways in which the disease may be introduced into new areas, the commonest being by means of infected seed or seedlings, or by contaminated animal manures. It may also be transported in soil attached to the roots of seedlings or adhering to farm implements, or carried by flood or irrigation waters.

Control.

As the organism responsible is a soil inhabitant and develops within affected plants it cannot be controlled by sprays. The following measures should be adopted as routine procedure in the commercial growing of tomatoes.

1. Carefully select fruit for seed from disease-free plants, or disinfect seed of doubtful origin or health.*

* Tomato seed may be disinfected by immersing and agitating in a one in three thousand solution of mercuric chloride (corrosive sublimate) for five minutes. The seed should then be washed for 15 minutes in clean running water and spread out thinly to dry in a cool shady place. The above solution may be prepared as follows:—Dissolve $\frac{3}{4}$ oz. of mercuric chloride in a quart of water; then take a $\frac{1}{2}$ pint of this stock solution and make up with water to 1 gallon 1 $\frac{1}{2}$ pints.

Note.—Mercuric chloride is poisonous. It will also corrode metals, hence only containers of glass, wood, earthenware or enamel may be used. Further details of seed and seedbed disinfection are obtainable in Department of Agriculture Leaflet No. 336.

2. Prepare fresh seed beds each year using either virgin or sterilised soil.†
3. Practise rotation of crops so that the land is cropped with tomatoes as infrequently as possible.
4. Do not feed infected plants to stock as the disease may be spread subsequently with the manure.
5. Remove and destroy diseased plants during the growing season, and when harvesting is over burn the crop remains. Also at this time sterilise the tomato stakes and seed-bed framework.
6. Resistant varieties are available for use on infected soil, but some of these are not as suitable as the commonly grown susceptible varieties. Also, probably owing to local variations in growing conditions and the occurrence of strains of the parasite which differ in virulence, varietal resistance may not be maintained in all areas. Growers should therefore test such varieties to decide which are most suitable. Varieties said to be resistant include:—

American: Marglobe, Potentate, Rutgers, Break o' Day, Marhio.

Australian: Australian Earliana, Early Dwarf Red.

BACTERIAL WILT OF TOMATOES.

Bacterial wilt of tomatoes is a serious disease which fortunately is so far of minor importance in W.A. when compared with either spotted or Fusarium wilt. The disease has only been found here in tomatoes and potatoes, but it can also attack many other plants, including:—Tobacco, eggplant, pepper, capsicum, black nightshade, thorn apple, peanut, and soybean. Although it was first recorded in this State many years ago, Bacterial wilt of tomatoes has since been noticed only infrequently from the Geraldton and metropolitan district.

Symptoms.

Usually the first symptom of the disease is the sudden wilting of the leaflets on an odd leaf or two, without any initial yellowing. This may occur at any part of the above ground portions of the plant, while the rest of the plant still looks quite healthy. If the attack is more severe the disease may first appear as a drooping or wilting of the whole plant.

Tomatoes affected with Bacterial wilt eventually die, but the foliage does not generally wither from below upwards as is generally the case with Fusarium wilt. The disease also produces a brown discoloration of the water-conducting tissues, and there is sometimes extensive destruction of the pith, leaving cavities in the stem. From the cut ends of stems or roots a greyish-white bacterial slime generally exudes, which characteristic helps to distinguish the disease from Fusarium wilt.

† Soil may be sterilised by steam, the most effective agent yet discovered, or by formalin. "To sterilise soil with formalin make up a 2 per cent. solution by adding one gallon of commercial formalin to 49 gallons of water. This solution is applied with a watering can to the soil which should previously have been well loosened up, at the rate of about one-half to one and one-half gallons of the solution to the square foot. The heavier the soil, the more needs to be used. The treated soil is then smoothed down and covered with bags moistened with the formalin solution, and left for several days. Forty-eight hours is usually enough, but no harm will be done if the covers are left on for a longer period. The bags are then removed and the soil thoroughly stirred with implements previously sterilised in steam, fire, boiling water, or formalin so as to let out the fumes. The stirring process should be repeated several times during the next ten days or a fortnight, after which the seeds may be safely sown." This treatment has been used a number of times in this State with great success.

Cause of the Disease.

The organism causing this disease (*Bacterium solanacearum*) is commonly spread to new areas by contaminated seed or soil. It attacks the roots of plants, especially through injuries, and gradually spreads through the water-conducting tissues. It may also be transmitted by chewing insects and by workers during pruning or other operations, and its spread in the field is generally attributed to these causes. The disease is encouraged by high temperatures, thriving best at about 95° F., and by wet weather; and it is generally said to be most serious in sandy soils.

The writer has had limited experience only of this disease locally and is anxious to obtain specimens. Recently cases were reported in which the disease appeared to be active at lower temperatures than usual. On potatoes the disease occurred on heavy soil and on tomatoes browning of the water-conducting tissues and bacterial slime production were inconspicuous. Possibly there are two rather similar diseases in W.A. or *B. solanacearum* may have slightly different environmental requirements.

Control.

The control measures for this disease are similar to those recommended for Fusarium wilt, but unfortunately resistant varieties are not available. In addition to these measures, however, chewing insects should be combated by either arsenate of lead containing dusts or sprays, and after handling diseased plants, workers' hands should be washed in warm soapy water.

Subterranean Clover Seed.

THE INFLUENCE OF SUPERPHOSPHATE ON GERMINATION.

G. R. W. MEADLY.

SUMMARY.

Literature pertaining to the effect of superphosphate on the viability of seeds is cited.

An experiment was conducted to test the germinating capacity of subterranean clover seed after having been in contact with both dry and moist super for varying periods of time. Both soil and blotting paper were used as germinating substrata and two different lines of superphosphates were involved.

With the soil tests, mixing with dry superphosphate did not affect the germination, even after seven days, but with moist superphosphate, although no decrease resulted after 24 hours, such was not the case after seven days. Although neither line affected the germination when dry, one had a greater harmful effect than the other when moist. This result was probably due, indirectly, to a higher initial moisture content of the more harmful line.

With the blotting paper tests there was no reduction in germination due to mixing with either sample of moist or dry superphosphate for 3-5 hours, or 24-26 hours. After several days, however, the moist and dry portions of both samples had caused a reduced germination. The degree of deterioration differed with the two samples and in each case a higher germination was secured with seed taken from the dry portion. The greater damage was caused again by the sample with the higher initial moisture content.

Providing the superphosphate is dry there is little or no risk due to contact between seed and super, even for a number of days. If the superphosphate is moist, however, the risk is increased appreciably, and contact for periods in excess of 24 hours should be avoided.

The effect of superphosphate on inoculating bacteria has been investigated by Cass Smith and Pittman (3). When it is desired to mix inoculated seed and superphosphate prior to sowing, both should be dry and sowing should take place into a thoroughly moist seed bed within half an hour of mixing.

INTRODUCTION.

Several papers have been written concerning the effect of superphosphate on the viability of seeds of various pasture species. Birks (2) showed that the vitality of rape seed was completely destroyed when seed was mixed with superphosphate and allowed to stand for periods varying from one to six days, the critical period depending upon the moisture content of the superphosphate. Seed sown with superphosphate in only partially moist sour soils also suffered serious adverse effects. Field results observed by Sherwin (5) in Tasmania indicated that a better stand of turnips was secured from two cwt. of basic superphosphate per acre prepared by mixing quantities of superphosphate and ground limestone than from 1 cwt. of superphosphate. In each case the seeds were mixed with the fertiliser before sowing and the improved crop was attributed to better seedling development. Whittet (6) found that superphosphate or sulphate of ammonia had practically no detrimental effect on white clover seed, even when in contact with it for seven days. Perennial rye grass seed was not affected by being mixed with the fertilisers for periods of four to 24 hours, but after being mixed with superphosphate for seven days, considerable reduction in viability resulted. Few viable seeds remained after 16 days. The germinating capacity of lucerne began to be detrimentally affected after being mixed with superphosphate for 36-48 hours. Ewart (4) stored dry wheat with an equal quantity of dry superphosphate for three to six weeks, but little or no injurious effect to the viability of the seed was indicated by germination tests. Adams (1) concluded from his experiments that leaving subterranean clover seed in superphosphate for 24 hours did not injure the seed, but a reduced germination resulted after nine days. He considered that some seeds of this species were easily damaged while others were very resistant. In 1938 the author conducted an exploratory experiment, mixing two lines of subterranean clover seed having a high and low hard seed content with standard and granular superphosphate, and basic superphosphate. The tests were not replicated, for which reason no figures are quoted, but no difference in germinating capacity was noted between controls and seeds removed from each fertiliser after 4 hours, 8 hours, 1, 2, 3, 7, and 14 days.

As mixing seed of subterranean clover with superphosphate before sowing is a common practice in this State, farmers have been enquiring recently concerning the effect of the superphosphate manufactured at the present time on the viability of the seed. Cass Smith and Pittman (3) have demonstrated clearly that the vitality of inoculating bacteria is impaired by mixing with superphosphate for periods as short as one hour, but no information was available concerning the effect of current lines of superphosphate on the actual seed viability.

EXPERIMENTAL PROCEDURE.

An experiment was designed to test the effect on the germinating capacity of mixing subterranean clover seed with moist and dry superphosphate for varying periods. Two different lines of superphosphate were used and the same procedure

was carried out for each: 100 grams were placed in flat porcelain dishes measuring 5in. x 5in; 10 mls. of water were added to half of these, and then 10 grams of subterranean clover seed was mixed thoroughly with the superphosphate in each dish. All were then covered with cardboard to prevent excessive evaporation from those which had been moistened.

As the removal and counting of the seeds occupy an appreciable period the time the seed remained mixed with the superphosphate is recorded as 3.5 hours, 24.26 hours, etc. One hundred and fifty seeds were removed from each tray during the times recorded, the removals being randomised to eliminate the time factor as far as possible. Three lots of fifty seeds from each dish were then placed on moist blotting paper in petri dishes and covered with bell jars. These were then placed in an incubator at 20° C. Particles of superphosphate adhering to a number of seeds taken from the moist superphosphate samples were not removed before placing them on the germinating substratum.

At the end of 24 hours a further series of seeds were removed and a germination test commenced on blotting paper. This was supplemented by a corresponding soil test, the soil being placed in petri dishes and covered with bell jars. A further double series was removed at the end of seven days. At this stage a small proportion of the seeds was enlarged and reddish, indicating water had been absorbed.

The soil tests at the end of one and seven days were included as the conditions for germination thus provided approximate more closely those experienced in the field than do blotting paper tests.

The following table gives the results of the various germination tests:—

Period in Super.	Substratum for Test.	Sample.	Superphosphate A. (moist) Germination.		Superphosphate A. (dry) Germination.		Superphosphate B. (moist) Germination.		Superphosphate B. (dry) Germination.	
			Sam- ple Av.	Mean Av.	Sam- ple Av.	Mean Av.	Sam- ple. Av.	Mean Av.	Sam- ple. Av.	Mean Av.
3.5 hours ...	Blotting paper	1	48	47 (94%)	48	48 (95%)	47	46 (93%)	47	48 (96%)
Do. ...	do. do.	2	46		48		47		48	
Do. ...	do. do.	3	48		46		46		49	
24.26 hours	Blotting paper	1	47	46 (93%)	48	47 (94%)	48	48 (96%)	50	49 (98%)
Do. ...	do. do.	2	47		46		48		49	
Do. ...	do. do.	3	45		47		47		49	
28.30 hours	Soil ...	1	46	46 (92%)	48	48 (96%)	47	47 (93%)	48	49 (97%)
Do. ...	do. ...	2	46		46		46		49	
Do. ...	do. ...	3	46		49		47		49	
7 days ...	Blotting Paper	1	34	31 (62%)	37	39 (78%)	36	33 (67%)	42	44 (87%)
Do. ...	do. do.	2	25		37		36		41	
Do. ...	do. do.	3	32		43		28		47	
7 days ...	Soil ...	1	40	39 (78%)	47	47 (94%)	43	44 (88%)	48	48 (97%)
Do. ...	do. ...	2	37		46		42		48	
Do. ...	do. ...	3	40		48		45		48	

Germination of original sample on blotting paper, av. 48 (96%).

ANALYSIS OF SUPERPHOSPHATE.

An analysis conducted by the Government Analyst defined the chemical composition of the two lines as follows:—

	A.	B.
	%	%
Total P_2O_5	18.47	21.78
Water soluble P_2O_5	16.33	19.31
Citrate soluble P_2O_5	1.18	1.55
Acid soluble P_2O_5	0.96	0.92
pH (glass electrode)	2.92	3.10
Moisture	3.5	1.6

RESULTS AND DISCUSSION.

In analysing the figures two separate experiments were considered, one in which the seeds were germinated on soil and the other in which blotting paper was the germinating substratum.

Experiment 1.—Soil substratum. The means were as follows:—

Separate Effects.

(a) Period of mixing with super—

28-30 hours	47
7 days	44

(b) Samples of super—

A.	45
B.	47

(c) Super (moist and dry)—

Moist	44
Dry	48

Interactions first order.

Period of mixing x samples—

Sample	Period of Mixing.	
	28-30 hours.	7 days.
A.	47	43
B.	48	46

Period of mixing x super, moist and dry—

	Period of Mixing.	
	28-30 hours.	7 days.
Moist	46	41
Dry	48	47

Samples x super (moist and dry)—

	Samples.	
	Super A.	Super B.
Moist	42	45
Dry	47	48

The main practical conclusions to be drawn from the figures are that mixing with dry superphosphate did not affect the germination even after seven days, but with moist superphosphate, although no decrease resulted after 24 hours, such was not the case after seven days. Although neither line affected the germination when dry, one had a greater harmful effect than the other when moist. As the line causing the greater damage had a higher initial moisture content (3.5 per cent. and 1.6 per cent.), the higher total moisture content may have been the influencing factor.

It is not suggested that the larger proportion of water directly caused the reduced germination, but rather that it dissolved and rendered active certain chemicals likely to prove injurious to the seed. Free sulphuric, hydrochloric and hydrofluoric acids are known to occur in superphosphate and although when in contact with subterranean clover seed for a short time they may actually stimulate germination by rendering the seed coat more permeable, if this period is extended, a stage may be reached when sufficient acid will be absorbed to weaken or even kill the embryo. The permeability of individual seed coats is variable as shown by "hard" and "semi-hard" seeds in standard germination tests and consequently the time which elapses before injury occurs is likely to be variable.

The experiment indicates, also, that an increase in the moisture content of superphosphate will induce increased absorption by the seeds and thus accentuate the damage caused by any injurious chemicals. Below a certain moisture level no absorption takes place or the intake is so slow that the seeds are not affected for an appreciable period. As the content rises above this critical level an increase in the rate of absorption must be expected along with a corresponding deterioration of the germinating capacity.

Experiment 2.—Blotting paper substratum. The means were as follows:—

Separate effects.

(a) Period of mixing with super—

3-5 hours	..	..	..	47
24-26 hours	..	..	..	48
7 days	..	..	..	36

(b) Samples of super—

A.	..	..	..	43
B.	..	..	..	45

(c) Super (moist and dry)—

Moist	..	..	..	42
Dry	..	..	..	46

Interaction first order.

Period of mixing x moist and dry—

		Period of Mixing.		
		3-5 hours.	24-26 hours.	7 days.
Moist	..	47	47	32
Dry	..	48	48	41

There was no reduction in germination due to mixing with either sample of moist or dry superphosphate for 3-5 hours or 24-26 hours. After seven days, however, the moist and dry portions of both samples had caused a reduced germination. The degree of deterioration differed with the two samples and in each case a higher germination was secured with seed taken from the dry portion. The greater damage was caused again by sample A. with the higher initial moisture content. No definite explanation can be advanced for the higher germinations secured on soil compared with blotting paper after seven days in contact with superphosphate. Seed taken from both wet and dry superphosphate reacted in the same way although the dry superphosphate caused less reduction in each case, in fact, as stated previously, when seed taken from it was tested on soil a normal germination resulted.

It is difficult to suggest an explanation for this result although the soil certainly would have a greater buffering effect than the blotting paper with a tendency to render inactive acids which may have been present on the surface or in the superficial layers of the seed at the time of removal from the superphosphate.

CONCLUSIONS.

When a small seeds attachment for the drill is not available, frequently subterranean clover seed is mixed with and sown along with the superphosphate. A question often asked by farmers, especially in recent months, is, "will mixing before sowing harm the seed?"

The results of this experiment have shown that providing the superphosphate is dry there is little or no risk due to contact between seed and superphosphate for a number of days. When the superphosphate is moist, however, the danger is increased. A ten per cent. added moisture content caused an appreciable reduction in viability after seven days, although there was no effect after 24 hours.

No difficulty should be experienced by farmers who mix their seed and superphosphate in the drill box itself, providing the drill is "run out" if not to be used for a few days. Even if other methods are adopted, damage to the germinating capacity of the seed can be obviated by mixing only the day's requirements each morning.

The above statements apply to the effect of superphosphate on the viability of subterranean clover seed. Its effect on inoculating bacteria has been investigated by Cass Smith and Pittman, who recommend that when it is desired to mix inoculated seed and superphosphate prior to sowing, both should be dry and sowing should take place into a thoroughly moist seed bed within half an hour of mixing. Leaflet No. 584 provides details of this aspect.

ACKNOWLEDGMENTS.

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Worms in Pigs.

C. R. TOOP, Senior Veterinary Surgeon.

The only internal parasite of economic importance occurring in pigs in Western Australia is the large roundworm—*Ascaris lumbricoides*. This parasite is widely distributed and occurs in most areas where pig raising is practised. Heavy infestations may be responsible for considerable economic loss. Young pigs are particularly susceptible and in consequence their development is severely retarded. Infested animals become stunted in growth and unthrifty in appearance. Mortality may occasionally occur amongst very young pigs.

These large worms occur in the small intestine. They are creamy white in colour, cylindrical in form and taper to a point at both ends. The average length is between six and 10 inches. Some may attain a length of 15 inches.

LIFE HISTORY.

The female worm is a prolific egg layer and may produce as many as 200,000 eggs daily. These are passed out with the droppings and contaminate the soil. In from 10 to 40 days or longer after reaching the exterior, the eggs develop to the infective stage when they are found to contain a larval parasite coiled up within the shell. These eggs are extremely resistant and may remain viable for several years. When, however, they are exposed to direct sunlight under hot, dry conditions they are unlikely to survive for more than a few weeks.

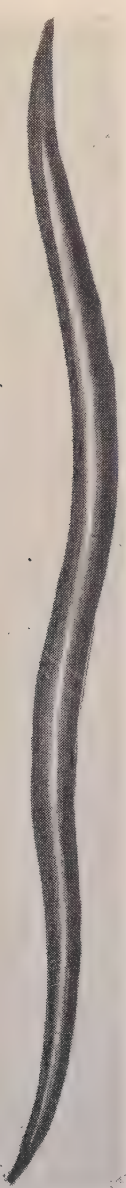
Infective eggs are swallowed with the food or water and in the case of young pigs may be picked up from the teats of the sow during feeding. Upon reaching the small intestine of the pig the eggs hatch, and the larvæ are set free. They burrow into the wall of the intestine and reach the blood vessels by which means they are carried to the liver and then via the heart to the lungs. Here they pass from the blood vessels to the alveoli or air sacs of the lung, and after undergoing further growth and development migrate up the trachea (windpipe), are swallowed, and pass down to the small intestine. Here they remain and grow to maturity.

SYMPTOMS.

The effects of the parasite are almost entirely confined to pigs under four months old. Although older animals may harbor the worms in quite considerable numbers they rarely suffer any ill effects.

In the case of young pigs growth is seriously impaired, and the animals become unprofitable. They remain stunted and unthrifty; the coat is rough and the animal has a pot-bellied appearance.

During their migration through the liver and lungs the larval worms inflict considerable injury which may prove fatal to young pigs during the first weeks of life. Pneumonia may develop as a sequel to the lung damage. In young pigs the invasion of the lungs by large numbers of larvæ may set up symptoms of laboured and forced respiration, this condition being commonly



The large round worm of the pig
Ascaris lumbricoides.

known as "thumps." The development of pneumonia is denoted by the presence of a short hard cough which is particularly noticed after exertion. It must, however, be pointed out that the symptom of coughing so prevalent amongst young pigs is frequently due to infectious pneumonia and is not in any way related to the invasion of the lungs by ascarid larvæ.



Drenching a young pig.

DIAGNOSIS.

When the presence of roundworms is suspected the diagnosis may be confirmed by the slaughter and post mortem examination of an animal showing typical symptoms. The worms will be found in the small intestine or "runners" which extends from the stomach to the caecum or blind gut. This portion of the intestine should be freed from its attachments and opened with scissors. The parasites, when present, will not be overlooked on account of their large size. Occasionally worms which have wandered from their natural habitat in the small intestine may be found in the stomach or in the bile ducts of the liver.

Both the liver and lungs may show evidence of the injury inflicted by the larval worms during their migration. The surface of the liver may show the presence of whitish areas about $\frac{1}{4}$ in. diameter. These are popularly known as milk

spots. The lungs may show more or less extensive solid pneumonic areas which contrast sharply with the spongy normal lung tissue which surrounds them.

When a post mortem examination cannot be performed a diagnosis can usually be established by the examination of a sample of the droppings in the laboratory for the presence of worm eggs.

TREATMENT.

There are two drugs which may be relied upon to expel roundworms from the small intestine of the pig. These are oil of chenopodium and phenothiazine. Other drugs which have from time to time been recommended have not given satisfactory results in our hands.

Oil of chenopodium should be given with or followed by a purgative such as castor oil.

The following mixture will be found satisfactory:—

Oil of chenopodium	..	..	..	..	1 fluid ounce.
Castor oil	..	..	..	..	25 fluid ounces.

The mixture should be administered at the rate of one fluid ounce per 25 lbs. of live weight. A single dose cannot be relied upon to remove all of the parasites and a second treatment should be given after an interval of 10 days has elapsed. The pigs should be starved for 24 hours before treatment. Pigs under the age of six weeks should not be treated. In general it will be found necessary to treat only weaners and slips. The drench may very conveniently be administered by means of a metal sheep drenching gun which may be set to deliver the required dose. During treatment young pigs may be held in an upright position with the buttocks resting on the ground between the knees of an assistant. Should the treatment of larger pigs become necessary these may be restrained by means of a running noose passing behind the tusks of the upper jaw and secured to a strong post.

Phenothiazine is a powdered drug which may be administered in the feed. The following dosage is advised:—

For pigs weighing 25 lbs.	..	..	..	1/6 ounce.
For pigs weighing 25-50 lbs.	..	..	1/4 ounce.	
For pigs weighing 50-100 lbs.	..	..	1/2 ounce.	
For pigs weighing 100-200 lbs.	..	..	3/4 ounce.	
For pigs weighing over 200 lbs.	..	..	1 ounce.	

Prior to treatment the pigs should be starved overnight and then graded according to their size. They should be treated in small groups which will ensure that each animal consumes an approximately equal share of the food material offered. According to the size and number of pigs in each group the required amount of the drug should be thoroughly mixed in an amount of food which will readily be consumed. As an example weaners weighing 25 lbs. could be treated in groups of six, allowing each group one ounce of phenothiazine incorporated in the feed. Treatment should be repeated after an interval of 10 days. Pigs under six weeks old should not be treated.

Following the administration of phenothiazine red colored urine is excreted for a period of four or five days. This does not denote any interference with the health of the animal and need cause no concern.

PREVENTION AND CONTROL.

On old established piggeries the soil becomes heavily contaminated with worm eggs. Consequently the young pigs which are highly susceptible are exposed to infestation from the time of birth. While treatment will remove the adult worms from the intestine it can have no effect upon the larval parasites which seriously damage the lungs and liver during their migration. It, therefore, becomes necessary to adopt preventive measures. Good sanitation, including the drainage of yards with the object of keeping them dry, the daily removal of droppings, the provision of sties with concrete floors and of troughs which will prevent the animals feeding off the ground will assist in limiting the degree of infestation. Much better results will, however, be obtained if it is possible to completely protect the young pigs from infestation. The MacLean County system which has been extensively and successfully practised in the United States has this object in view. Its purpose is to prevent the exposure of the young pigs to infection from the time of birth until they are four or five months old.

The following procedure is adopted:—

Farrowing pens with concrete floors are provided. A few days before farrowing is due to occur the floor and walls are thoroughly cleansed by washing with a boiling 5% Kerol solution (8 ounces to the gallon of water) applied with a hard broom. Immediately before being placed in the farrowing pen the sow is washed with a warm solution of soap and water, all mud and litter being removed, particular attention being paid to the cleansing of the udder and teats. This will remove any worm eggs which may be adhering to the body of the animal. Within 10 days of farrowing the sow and her litter are carted to a clean field or a field which has been sown with a green crop and has not been occupied by pigs within the past year. The matter may be placed on a very satisfactory basis if three pig paddocks can be made available and used in annual rotation. The paddock intended for the reception of sows and their litters should be cultivated and sown with a suitable green crop, the other two paddocks remaining vacant. On this basis each of the paddocks will be used every third year and will remain unoccupied during the remaining two years, when it may be used for the production of other farm crops. Under such a system of rotation and cultivation few worm eggs will remain viable and the young pigs may be carried to the age of four or five months without becoming seriously affected. Thereafter the animals, which are no longer highly susceptible, may be transferred to the old yards or sties for fattening purposes.



Pig Feeding Trial at Muresk Agricultural College.

DEMONSTRATION IN THE USE OF MEAT MEAL AS A SUPPLEMENT TO WHEAT.

M. CULLITY, Superintendent of Dairying.

C. R. DIXON, Pig Husbandryman.

The possibility of increasing the number of bacon pigs which are produced in the wheatgrowing districts has been discussed on many occasions. It has been suggested that by giving more attention to pig raising farmers could ease the marketing difficulties associated with the surplus production of wheat and add some security to their operations. While the fallacy of feeding wheat alone is known to most farmers, there is apparently a large number who do not understand how wheat may be used with proper supplements in order to obtain rapid and economical growth.

The report of Hughes and Dixon showed that the use with wheat of a protein supplement—such as skim milk or meatmeal—was necessary for feeding bacon pigs. However, at the present time meatmeal is not plentiful and it is desired that the available supplies should be used to the greatest advantage.

The present trial may be considered exploratory in an endeavour to determine whether the proportion of meatmeal fed in the earlier experiment could be reduced without affecting adversely the profit from the pig or the quality of its carcass.

Twenty-four pigs were selected from the litters of one Berkshire and two Tamworth sows, which had been mated to a Berkshire boar.

From the date of mating until a few days before farrowing, the sows were run in paddocks where green grazing was available.

A few days prior to farrowing they were brought into the pens and remained there for one week after the litters were born, when they were moved to small yards until the piglets were one month old.

The sows and litters then were put into paddocks of green oats and capeweed until the date of weaning.

As the young pigs were weaned, they were divided as evenly as possible according to weight into four groups, there being two pigs from each litter in each group.

From the commencement of the trial each group was fed separately as much as the pigs would consume in two periods each of twenty minutes. Water was available at all times.

The ration for each group was varied as follows:—

Group 1.—Mixture of wheat and meatmeal in a ratio of 2 : 1 for the first week; thereafter the proportion of meatmeal was gradually reduced until the final week when the ratio was 10 : 1.

Group 2.—A mixture of wheat and meatmeal in a ratio of 9 : 1 for four weeks, the meatmeal then being reduced to 16 : 1 for the fifth week, and thereafter until the end of the trial the meatmeal was further reduced to a ratio of 24 : 1.

Group 3.—A mixture of wheat and meatmeal in the ratio of 9 : 1 for four weeks after the commencement of the trial: from that time until the end of the experiment this group received wheat only.



Fig. 1.
Groups 1 to 4 (from top to bottom).

Group 4.—Wheat only.

The composition of the wheat and meatmeal was determined in the Government Chemical Laboratory as follows:—

Wheat—Water, 5.78; ash, 14.03; ether extract, 22.32; fibre, 2.88; protein, 52.88

Meatmeal—Water, 10.23; ash, 1.91; ether extract, 2.94; fibre, 3.56; protein, 11.6.

The percentage of protein in the rations of the various groups is given hereunder:—

Group 1.—25.3 per cent. at the start, then reduced gradually throughout the trial to 15.3 per cent.

Group 2.—15.7 per cent. for the first four weeks, 14.0 per cent. for the fifth week, and thereafter 13.2 per cent.

Group 3.—15.7 per cent. for the first four weeks, thereafter 11.6 per cent.

Group 4.—11.6 per cent.

A mineral supplement (Di-calcic Lick) was included in the ration of each group and comprised $2\frac{1}{2}$ per cent. of the total ration.

Greater quantities of food were consumed as the pigs grew, and, owing to the greater rapidity of growth of Groups 1 and 2, their requirements of food became proportionately greater until at the end of the trial they were consuming slightly more than twice the amount used by Groups 3 and 4. The actual quantities consumed by each group are shown in Table 5.

WEIGHTS OF INDIVIDUAL PIGS IN EACH GROUP.

TABLE 1.

GROUP 1.

Ration, Crushed Wheat and Meatmeal. (For details see Table 5.)

Weight Week ending.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average.	Average Gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8th September ...	49	33	42	48	38	41	41.83	...
15th September ...	49	36	40	47	42	43	42.83	1.0
22nd September ...	55	42	44	50	43	50	47.33	4.5
29th September ...	61	46	46	55	47	54	51.5	4.16
6th October ...	69	56	58	64	57	68	62.0	10.5
13th October ...	74	60	65	67	61	78	67.5	5.5
20th October ...	82	70	70	74	68	84	74.66	7.16
27th October ...	90	77	76	83	77	93	83.0	8.33
3rd November ...	99	90	88	92	85	107	93.5	10.5
10th November ...	109	99	99	103	98	116	104.0	10.5
17th November ...	118	107	104	109	104	120	110.33	6.33
24th November ...	126	116	112	121	110	134	119.83	9.5
1st December ...	137	121	120	126	120	145	128.16	8.33
8th December ...	143	137	135	141	128	160	140.66	12.5
15th December ...	154	146	142	152	136	167	149.5	8.83
22nd December ...	166	158	155	164	147	177	161.16	11.66
29th December ...	181	166	169	170	160	190	172.66	11.5
5th January ...	194	176	177	180	168	204	183.16	10.5
12th January ...	199	186	190	190	178	219	193.66	10.5

WEIGHTS OF INDIVIDUAL PIGS IN EACH GROUP—*continued*.

TABLE 2.

GROUP 2.

Ration, Crushed Wheat and Meatmeal. (For details see Table 5.)

Weight Week ending.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average.	Average Gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8th September ...	41	40	41	38	38	50	41·33	...
15th September ...	41	40	39	37	38	50	40·83	·5
22nd September ...	45	45	43	42	42	55	45·33	4·5
29th September ...	47	48	46	45	46	56	48·0	2·66
6th October ...	56	59	55	54	54	64	57·0	9·0
13th October ...	58	66	60	63	60	69	62·66	5·66
20th October ...	66	73	67	64	58	75	67·16	4·5
27th October ...	77	85	77	67	60	89	75·83	8·66
3rd November ...	84	93	83	72	57	96	80·83	5·0
10th November ...	94	104	93	81	61	107	90·0	9·16
17th November ...	97	108	95	87	61	108	92·66	2·66
24th November ...	105	117	103	97	70	121	102·16	9·5
1st December ...	114	128	113	105	76	127	110·5	8·33
8th December ...	123	140	123	116	83	137	120·33	9·83
15th December ...	126	146	133	127	90	149	128·5	8·16
22nd December ...	133	154	142	138	94	159	136·66	8·16
29th December ...	141	164	150	153	100	170	146·33	9·66
5th January ...	149	176	161	162	112	176	156·0	9·66
12th January ...	156	181	171	173	117	194	165·33	9·33

TABLE 3.

GROUP 3.

Ration, Crushed Wheat with addition of Meatmeal for one month only. (For details see Table 5.)

Weight Week ending.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average.	Average Gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8th September ...	45	41	36	42	41	42	41·16	...
15th September ...	45	41	34	39	41	41	40·16	1·0
22nd September ...	49	44	37	42	44	45	43·5	3·33
29th September ...	56	50	43	43	49	49	48·83	4·83
6th October ...	66	59	50	48	57	56	56·0	7·66
13th October ...	69	61	50	48	57	59	57·33	1·33
20th October ...	72	63	52	47	60	60	59·0	1·66
27th October ...	79	69	56	52	67	66	64·83	5·83
3rd November ...	85	71	59	52	68	69	67·33	2·50
10th November ...	89	75	60	52	72	72	70·0	2·66
17th November ...	98	82	64	55	77	78	75·66	5·66
24th November ...	102	82	60	53	78	79	75·66	...
1st December ...	104	85	65	54	84	85	79·5	3·83
8th December ...	110	85	64	53	83	84	79·83	·33
15th December ...	114	94	69	58	88	92	85·83	6·0
22nd December ...	120	99	69	55	92	93	88·0	2·16
29th December ...	124	102	60	60	97	96	89·83	1·83
5th January ...	129	107	71	60	102	102	95·16	5·33
12th January ...	133	109	72	60	104	104	97·0	1·83

WEIGHTS OF INDIVIDUAL PIGS IN EACH GROUP—*continued*.

TABLE 4.

GROUP 4.

Ration. Wheat only. (For details see Table 5.)

Weight Week ending.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average.	Average Gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8th September ...	43	38	43	44	40	41	40.5	...
15th September ...	42	37	39	43	39	41	40.16	.33
22nd September ...	44	39	39	48	41	43	42.33	2.16
29th September ...	46	41	42	51	43	45	44.66	2.33
6th October ...	51	45	48	57	47	52	50.0	5.33
13th October ...	52	47	51	61	50	54	52.5	2.5
20th October ...	54	48	53	65	51	58	54.83	2.33
27th October ...	58	50	58	68	54	64	58.66	3.83
3rd November ...	58	50	60	72	54	67	60.16	1.5
10th November ...	60	52	63	74	57	74	63.33	3.16
17th November ...	64	56	68	80	60	79	67.83	4.5
24th November ...	63	52	67	83	58	81	67.33	.5
1st December ...	63	53	69	81	59	83	68.0	.66
8th December ...	63	53	70	82	65	87	70.0	2.0
15th December ...	66	57	75	88	64	91	73.5	3.5
22nd December ...	66	56	76	89	62	93	73.66	.16
29th December ...	66	57	76	91	64	966	75.0	1.33
5th January ...	70	60	81	95	66	104	79.33	4.33
12th January ...	70	60	81	96	66	106	79.83	.5

TABLE 5.

RATIONS FED TO PIGS IN EACH GROUP.

Date.	GROUP 1.		GROUP 2.		GROUP 3.		GROUP 4.
	Per Pig per Day.		Per Pig per Day.		Per Pig per Day.		Per Pig per Day.
	Grain.	Meat-meal.	Grain.	Meat-meal.	Grain.	Meat-meal.	Grain only.
				(9 parts) (1 part)		(9 parts) (1 part)	
Week ending—							
15th September ...	$\frac{1}{2}$ lb.	$\frac{1}{4}$ lb.	$\frac{3}{4}$ lb. mixture		$\frac{3}{4}$ lb. mixture		$\frac{3}{4}$ lb.
22nd September ...	1 lb.	$\frac{1}{2}$ lb.	1 $\frac{1}{2}$ lbs. "		1 $\frac{1}{2}$ lbs. "		1 $\frac{1}{2}$ lbs.
29th September ...	1 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	2 lbs. "		2 lbs. "		1 $\frac{1}{2}$ lbs.
6th October ...	2 lbs.	$\frac{1}{2}$ lb.	2 $\frac{1}{2}$ lbs. "		2 $\frac{1}{2}$ lbs. "		1 $\frac{3}{4}$ lbs.
13th October ...	2 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	(16 parts) (1 part) 3 lbs. mixture		Grain only. 2 $\frac{1}{4}$ lbs.		1 $\frac{3}{4}$ lbs.
20th October ...	2 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	(24 parts) (1 part) 3 lbs. mixture		2 $\frac{1}{4}$ lbs.		2 lbs.
27th October ...	3 lbs.	$\frac{1}{2}$ lb.	3 $\frac{1}{2}$ lbs. "		2 $\frac{1}{4}$ lbs.		2 lbs.
3rd November ...	3 lbs.	$\frac{1}{2}$ lb.	3 $\frac{1}{2}$ lbs. "		2 $\frac{1}{2}$ lbs.		2 lbs.
10th November ...	3 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	4 lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{4}$ lbs.
17th November ...	3 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	4 lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{4}$ lbs.
24th November ...	4 lbs.	$\frac{1}{2}$ lb.	4 $\frac{1}{2}$ lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{4}$ lbs.
1st December ...	4 lbs.	$\frac{1}{2}$ lb.	4 $\frac{1}{2}$ lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{2}$ lbs.
8th December ...	4 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	5 lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{2}$ lbs.
15th December ...	4 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	5 lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{2}$ lbs.
22nd December ...	4 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	5 $\frac{1}{2}$ lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{2}$ lbs.
29th December ...	4 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	5 $\frac{1}{2}$ lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{2}$ lbs.
5th January ...	4 $\frac{1}{2}$ lbs.	$\frac{1}{2}$ lb.	5 $\frac{1}{2}$ lbs. "		2 $\frac{1}{2}$ lbs.		2 $\frac{1}{2}$ lbs.
12th January ...	5 lbs.	$\frac{1}{2}$ lb.	5 $\frac{1}{2}$ lbs. "		2 $\frac{3}{4}$ lbs.		2 $\frac{1}{2}$ lbs.



Fig. 2. Group 1.

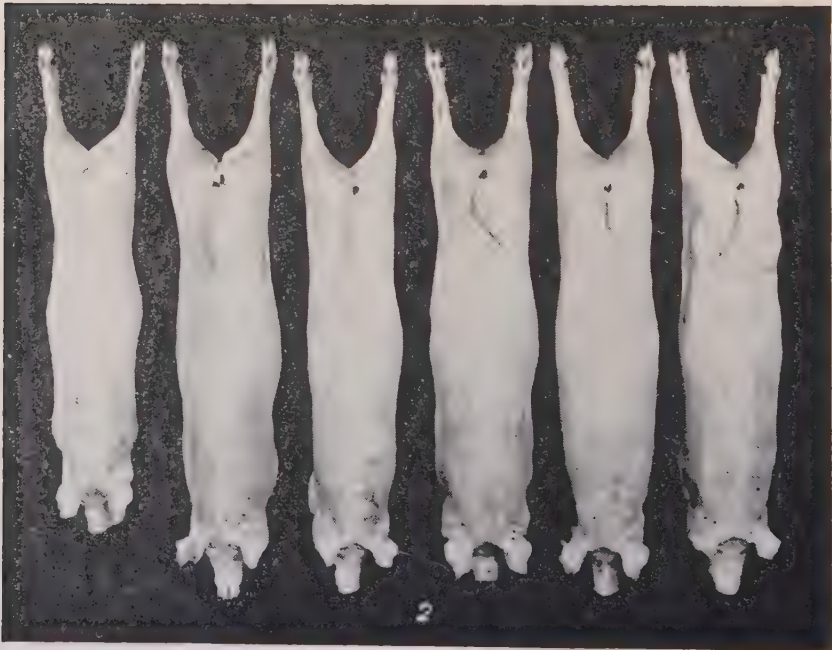


Fig 3 Group 2.



Fig. 4. Group 3.

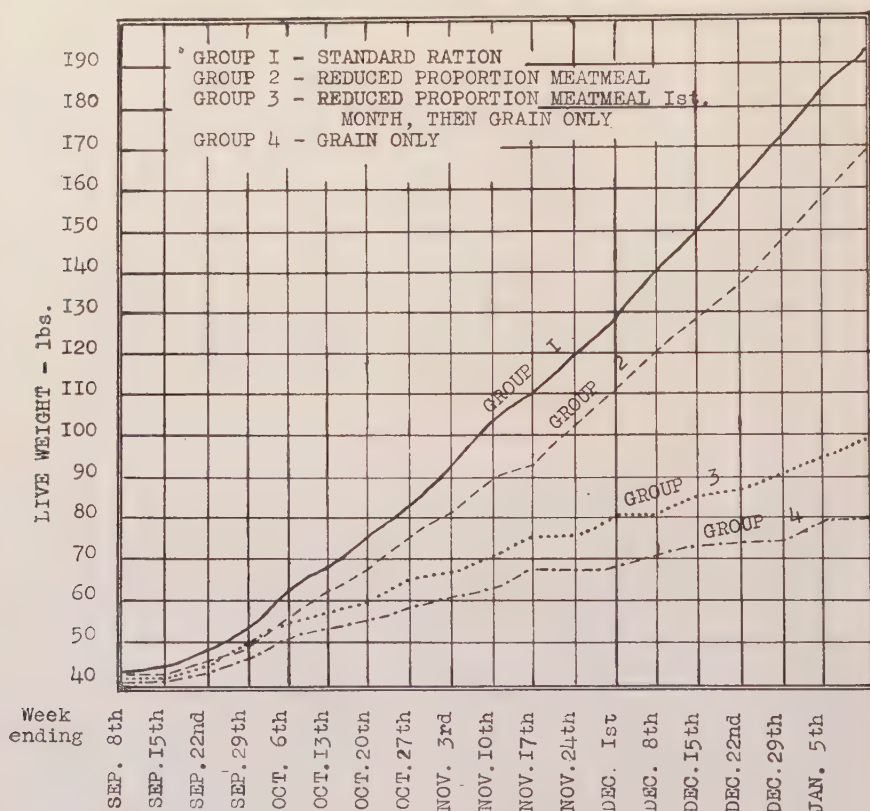


Fig. 5. Group 4.

All the pigs were weighed at weekly intervals, and the details of their weights are shown in Tables 1, 2, 3, and 4.

At the commencement of the trial the average weights of the pigs in the various groups were very even, but as feeding progressed differences in the rate of gain were noticed quickly, and it was obvious that Group 4, receiving no meatmeal were not as thrifty as the animals in the other pens. After the lapse of two months, a slight unthriftiness became discernible in the animals of Group 3 which had received meatmeal for the first month only.

The comparative rates of growth are shown in the accompanying graph.



CURVES OF WEIGHT INCREASES.

A study of this graph shows several interesting features.

The rate of growth of Group 1 receiving the greatest amount of protein was the most rapid of all the groups, while the inclusion of only one part of meatmeal in 24 parts of wheat—giving a mixture having 13.2 per cent. of protein—was responsible for markedly superior growth than where wheat alone was fed, while the group receiving this ration was definitely inferior to Group 1. In Group 3 is noticed probably the most interesting features. While the wheat-meatmeal mixture was being fed, the rate of growth was almost equal to that of Group 1, but as soon as the feeding of this supplement ceased, the rate of growth slowed down markedly and the average weights quickly fell below that of Group 2.

It should be noted that the quantity of meatmeal fed in the first month to Group 3 was the same as that fed to Group 2, but considerably less than that used in the ration for Group 1.

It was intended originally that all pigs should be slaughtered when the average weight of group 1 was approximately 120 lbs. dead weight. However, owing to unforeseen difficulties it was not possible to send the pigs to the treatment works for almost three weeks after this weight had been reached.

All pigs were forwarded to the Watsonia Bacon Factory on 11th January and were slaughtered on 13th January. The difference in the live weights as despatched from the College and their dead weights (cold) is given hereunder, together with a record of their grading for disposal, the prices paid and their value.

TABLE 6.

Group No.	No. of Pigs in Group.	Live Weight.	Dressed Weight.	Grading.	Price	Value.
		lbs.	lbs.		per lb.	£ s. d.
1	1	199	151	1st Wiltshire	6½d.	4 4 11
	2	186	139	do.	6½d.	3 18 2
	3	190	141	1st Bacon	7½d.	4 8 2
	4	190	140	do.	7½d.	4 7 6
	5	178	130	do.	7½d.	4 1 3
	6	219	161	1st Wiltshire	6½d.	4 10 7
						£25 10 7

Average Dressing Percentage—74·2 per cent.

2	1	156	116	1st Wiltshire	6 $\frac{1}{4}$ d.	3 5 3
	2	181	139	do.	6 $\frac{1}{4}$ d.	3 18 2
	3	171	127	do.	6 $\frac{1}{4}$ d.	3 11 5
	4	173	128 { 64	do.	6 $\frac{1}{4}$ d.	} 3 6 8
			64	One side reject	5 $\frac{1}{4}$ d.	
	5	117	86	1st Bacon	7 $\frac{1}{4}$ d.	2 13 9
	6	194	149	1st Wiltshire	6 $\frac{1}{4}$ d.	4 3 10
						£20 19 1

Average Dressing Percentage—75.1 per cent.

3	1	133	99	1st Bacon lowest range	...	7½d.	3	1	11
	2	109	84	do.	do.	7½d.	2	12	6
	3	72	55	1st Pork storage Darwin pork	...	7½d.	1	14	5
	4	60	43	do.	do.	7½d.	1	6	10
	5	104	79	1st Bacon lowest range	...	7½d.	2	9	4
	6	104	77	do.	do.	7½d.	2	8	2
							£13 13 2		

Average Draining Percentage—75.1 per cent.

4	1	70	53	1st Pork storage Darwin pork	7½d.	1 13 2
	2	60	41	do. do. ...	7½d.	1 5 7
	3	81	60 { 30	1st Bacon lowest range ...	7½d.	} 1 17 6
			30 { 30	Darwin pork ...	7½d.	
	4	96	73	1st Pork storage Darwin pork	7½d.	2 5 8
	5	66	49	do. do. ...	7½d.	1 10 7
	6	106	81	1st Bacon lowest range ...	7½d.	2 10 8
						£11 3 2

Average Dressing Percentage—74·5 per cent.

A record of the cost of the foodstuffs used was kept, and thus it has been possible to compare the profit over the cost of feed for each group.

TABLE 7.
PROFIT OVER COST OF FEED.

Group No.	Value of Pigs.	Cost of Feed.	Margin—Value over Cost of Feed.
	£ s. d.	£ s. d.	£ s. d.
Group 1	25 10 7	9 2 0	16 8 7
Group 2	20 19 1	8 17 2	12 1 7
Group 3	13 13 2	5 6 1	8 7 1
Group 4	11 3 2	4 8 0	6 15 1

Further details showing the average weight increase for each pig, the quantity of grain and meal consumed during the trial and also calculated per pound of live weight increase, together with the cost of feed per pound of live weight increase are given in Table 8.

TABLE 8.

	Group 1.	Group 2.	Group 3.	Group 4.
Average weight at weaning (lbs.)	41.8	41.3	41.2	40.5
Average weight at end of trial (lbs.) ...	193.7	165.3	97.0	79.8
Average gain per pig (lbs.)	151.9	124.0	55.8	39.3
Amount crushed wheat consumed per pig (lbs.)	414.7	453.8	285.8	262.5
Amount meal consumed per pig (lbs.) ...	61.2	22.2	4.7	...
Weight of feed per pound live weight increase (lbs.)	3.1	3.8	5.2	6.6
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total cost of feed per pig	1 10 4	1 9 6	0 17 8	0 14 8
Average cost per pound live weight increase (pence)	2.4	2.8	3.9	4.4

Photographs of the live pigs and of the carcasses are shown in Figures 1 to 8.

The carcasses selected for Figures 6, 7, and 8 were those which approached most nearly to the average weight of each group. When the carcasses were cut down, measurements of the length of the sides, the width of the eye muscle, and the depth of the backfat were made and are shown in Table 9 together with an external measurement of all carcasses from the poll to the butt of the tail.

Discussion.

The evidence which has been obtained confirms the previous conclusions that meal can be used successfully as a supplement to wheat. The rates of growth and development of groups 1 and 4, those receiving an ample supply of meal and those receiving wheat only, are so widely different that if there was no other data available only one conclusion could be drawn, that the feeding of wheat alone is a most unprofitable method of feeding pigs.

Of the three groups receiving meal, group 1 made the most rapid growth, produced the best carcasses and returned the greatest profit over the cost of feed: group 2, which received a reduced proportion of meal throughout the trial, made relatively rapid growth, but not quite so rapid as group 1.

TABLE 9.

Group No.	Pen.	Dead Weight. (Average —Cold)	Tail Butt to Poll. (Average)	Length Aitch-bone to Symphysis 1st Rib and Sternum.	Aitchbone to Toe.	Depth Eye Muscle.	Back Fat.
1	1	lbs. 161	inches. 42	mm.	mm.	mm.	mm.
	2	139	39	719	550	43	32
	3	141	39				
	4	140	39				
	5	130	40				
	6	151	40				
	Average	144 $\frac{1}{2}$	39 $\frac{1}{2}$				
2	1	149	40	700	537	32	42
	2	127	38				
	3	86	35				
	4	116	38				
	5	128	38				
	6	139	39				
	Average	124 $\frac{1}{2}$	38				
3	1	99	37	625	462	31	24
	2	55	32				
	3	84	35				
	4	79	34				
	5	77	33				
	6	43	27				
	Average	73	33				
4	1	53	32	575	488	26	19
	2	41	29				
	3	60	32				
	4	73	33				
	5	49	31				
	6	81	33				
	Average	59 $\frac{3}{4}$	31 $\frac{3}{4}$				

The quantity of food consumed per pound of live weight gain was the lowest in group 1, 3.1 lbs. of the ration mixture being required for each pound increase in weight. It will be noticed that the utilisation of food by groups 3 and 4 was particularly poor. The pigs in group 3 grew more rapidly for the first month than those in group 4, due to the inclusion of some meatmeal in their ration during that period. Being larger in size at the end of the month, their requirement for food was proportionately greater, while the rate of increase in weight from that time on to the end of the trial was no faster.

The total cost of feeding each pig was greatest in group 1 and the lowest in group 4, but owing to the greater rapidity of growth in the former group, the cost of food per pound of live weight increase, was lower than in the other groups. The cost of feed for each pound of gain increased as the proportion of meatmeal was reduced and was highest where wheat only was used.

It is therefore apparent that under conditions similar to those in the wheatbelt, the provision of meatmeal is not an added expense in feeding pigs, but is actually a means of reducing costs of production.



Fig. 6.

An average carcass from each group. Groups 1 to 4 from right to left.

In an earlier trial at the Muresk Agricultural College (Hughes and Dixon) where no protein supplement was used in the grain allowance, only 3.93 lbs. of wheat were required to produce one pound of live weight gain, whereas in the present trial 6.6 lbs. of grain were needed. In the earlier trial, however, a quantity of green fodder, principally lucerne, was allowed to all pigs daily. This, no doubt, was largely responsible for the better utilisation of the wheat.

On slaughter there was no significant difference in the dressing percentage of the various groups.

The quality of the carcasses of group 2 were found to be generally inferior to those of group 1—see Table 6. Three of the six carcasses of the latter group were considered suitable as first grade for the local bacon trade and the other three were suitable for the export trade as first grade Wiltshire sides and one only (a light carcass) as fit for the local trade. It is explained that on a perusal of weight alone it might be considered that group 2, averaging 124½ lbs. per carcass, would be generally more suitable for the local trade than group 1, which averaged 144⅓ lbs. per carcass—as normally it is the heavier and usually fatter pigs which are exported, while the lighter, less fat pigs are retained for the local market. In this trial, however, the heavier pigs of group 1 were considered more suitable for the local trade than the lighter pigs of group 2. This classification was due to the relatively fatter condition of the carcasses of this latter group.

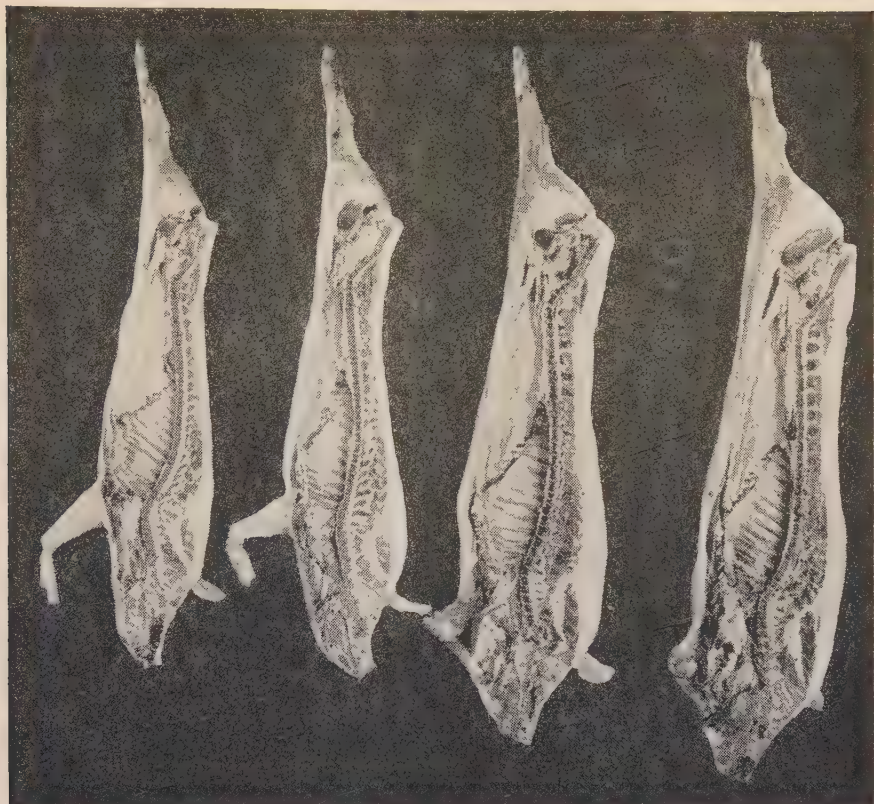


Fig. 7.

The carcasses in Fig. 5 were cut down. The sides are Groups 1 to 4 from right to left.

Although it was not possible to cut down each carcass for measurement, the details of the representative carcasses shown in Table 9 are interesting. The carcass nearest the average weight of each group was cut down into sides and again through the loin to enable photographs to be taken. Measurements of these sides indicated that the side from group 1 was considerably longer (19 m.m. or nearly $\frac{4}{5}$ ths of an inch) than that representing group 2. That this is probably a true index of the average for the whole of the groups is supported by the external measurements from poll to the base of the tail, which showed the pigs of group 1 to be $1\frac{5}{6}$ ths inches longer than those of group 2. This comparison may be seen in Figures 6, 7, and 8, showing the carcasses, the sides and cuts through the loin of the four representative carcasses. It will be noticed that the depth of back fat in the sides is greatest in that from group 2, while the width of the eye muscle in the loin cuts is greatest in that representing group 1. From Table 9 it may be seen also that the respective depths of back fat in groups 1 and 2 are 32 m.m. and 42 m.m. respectively, the eye muscle measurements were 43 m.m. and 32 m.m. respectively. It appears reasonably conclusive, therefore, that the proportion of meatmeal fed to group 2 has not provided so satisfactory a result as that fed to group 1, and that if the proportion fed to group 1 is higher than necessary the amount of meatmeal fed cannot be reduced to the level of that fed to group 2 without affecting the rate of growth, the quality of the carcass and the profit.

In the feeding of group 3 an endeavour was made to ascertain whether it was necessary to feed meatmeal as a supplement throughout the period of growth of the bacon pig. From the results obtained it can be concluded that if meatmeal can be dispensed with, it cannot be left out of the ration as early as was the case in this trial.

It will be seen from figure 1 that while this group was receiving a ration of meatmeal its growth rate was intermediate between those of groups 1 and 2, but as soon as the ration was composed of grain alone an immediate slowing down of the growth rate occurred until it approximated that of group 4, which had not received any meatmeal at all. However the effect of meatmeal during the first month was evident in the increased growth of the pigs compared to those which received grain only. The average carcass weights were 72 and 59 lbs. respectively, while the average external length of the carcasses from poll to the butt of the tail was 33 and 31½ inches respectively. The eye muscle and the deposition of back-fat were both correspondingly greater. This result is no other than should be expected as it has been demonstrated so frequently that it is axiomatic that the young pig should be well fed on a narrower or higher protein ration than older pigs.



Fig. 8.

The sides in Fig. 6 were cut through at the last rib to show the backfat and the eye of meat. Groups 1 to 4 from left to right.

The examination of the carcasses showed that some were very good, judged on the requirements of the local market. However as the period during which the trial was to have been concluded had to be lengthened by three weeks for reasons beyond control, the unsuitability of some carcasses for the local trade cannot be presumed to indicate the unsuitability of the breeding animals nor of the method for feeding for this market. As the weight ranges of the two heavier groups tended toward Wiltshire side weights it can be accepted that the amount of fat present was not excessive, otherwise they would not have been graded as first grade. When comparisons are made between these carcasses and the ideal, as described by Hammond, et al, it is seen that some considerable improvement is required. The amount of meat in the eye muscle and in the streak in the carcasses of group 1, as shown in Figure 8 is satisfactory, but this needs further improvement with a corresponding decrease in the thickness of the back-fat before the ideal carcass has been produced. The development of strains of more lengthy pigs which will not carry excessive fat at marketable weights will assist to this end. This aspect is considered highly important, as if the pig industry in Western Australia is to be expanded after the war, it can only be on the basis of the export market where competition will be met from bacon produced in Canada and in Denmark, which has been proved to be suitable to the requirements of the British public.

For this reason the further trials which are planned to investigate whether the quantity of meatmeal in the ration of group 1 is the optimum or whether it can be reduced profitably will include the appraisal of the carcasses.

Summary.

A trial in which various proportions of meatmeal were fed to pigs receiving a basal ration of wheat is reported.

The rate of growth was most rapid and the greatest profit was returned in the group receiving the greatest proportion of meatmeal. The slowest growth and the lowest profit was recorded for the group receiving no meatmeal.

The necessity of supplying sufficient meatmeal in the ration of the young pig is shown by the marked change in the rate of growth of group 3, when the ration was altered from one including meatmeal to one of wheat only.

The carcasses from the group receiving the greatest amount of meatmeal showed a superior meat development to those in the other groups, while the greatest deposition of fat occurred in the carcasses from the group which received a greatly reduced proportion of meatmeal, but which allowed fairly rapid growth.

ACKNOWLEDGMENT.

The thanks of the authors are due to Mr. A. H. Watson of Watson's Supply Stores for permitting the use of the staff and facilities of the bacon factory at Spearwood during the slaughter and treatment of the pigs, and to the members of the factory staff for their ready co-operation.

Bean Rust.

W. P. CASS SMITH.

During February a serious epidemic of bean rust developed in market gardens chiefly in the Balcatta and Osborne Park districts. Many crops of runner beans were completely ruined, and in consequence market prices rose sharply.

A survey of the affected areas showed that plantings on muck, or peaty swamp soils, where atmospheric humidity was high, were more seriously damaged than those on light sandy soils under sprinklers, and that french bean varieties, though affected with the disease, were highly resistant compared with runner types. Apparently this constitutes the first authentic record of bean rust in Western Australia, but from inquiries made, it seems reasonably certain that it has been present in the metropolitan area for several years at least to a limited extent. Many gardeners state that they have noticed the disease on occasions in the late autumn months; but that it caused little damage, as harvesting of all but late sown crops was then completed. Experience of the disease elsewhere gives added support to these observations, and it has been reported from New South Wales that bean rust is most serious there towards the end of the growing season, when it is more troublesome to home gardeners than to commercial growers.*

SYMPTOMS.

The disease may occur on any of the above-ground parts but it is most prevalent on the leaves. Practically all the injury is caused by leaf infections which, if numerous, may lead to complete defoliation. On the leaves the disease first appears in the form of small circular yellow spots which soon become raised, and later rupture, exposing the reddish-brown spore masses of the fungus. At first these spore-bearing pustules occur mainly on the undersides, but subsequently

*New South Wales Agric. Gaz., September, 1942, p. 428.

they develop on both surfaces of the leaves. (Plate 1.) On the pods, petioles, and stems the pustules are more irregular in shape and noticeably raised. (Plate 2.)

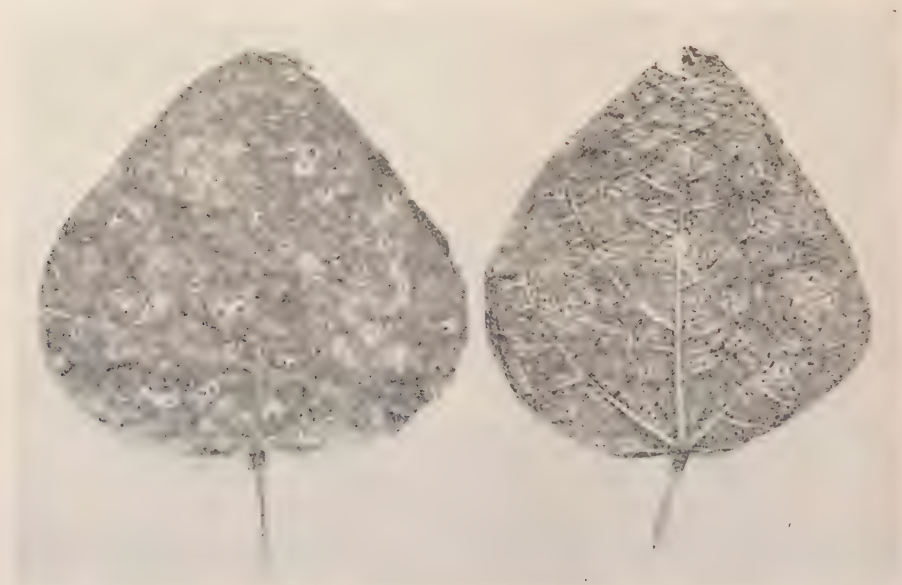


Plate 1.

Bean rust. Note at left on the upper leaf surface, circular yellow spots surrounding the rust pustules. At right note numerous spore-bearing pustules on the under surface.

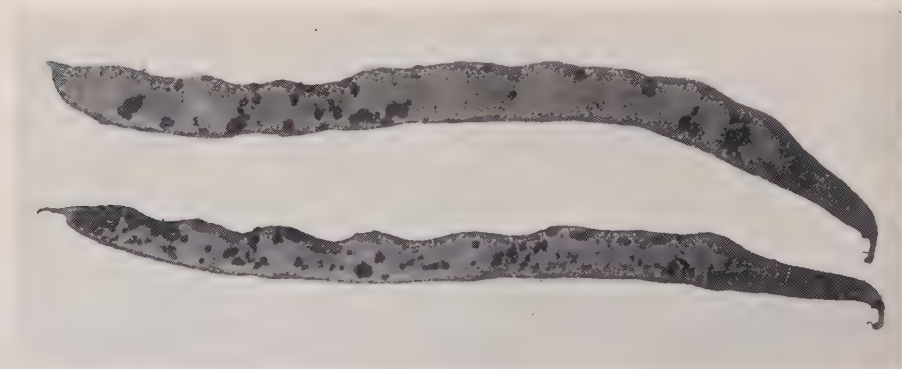


Plate 2.

Runner bean pods showing symptoms of rust. The pustules are raised and irregular in shape.

CAUSE.

Bean rust is caused by a fungus, *Uromyces appendiculatus* (Pers.) Fr. The reddish brown spores (uredospores) which are discharged in thousands from the pustules, are transmitted by wind, insects, rain, or other agencies, to neighbouring healthy plants where they may produce new infections. With suitable weather conditions the disease is rapidly spread by these spores, and in a few weeks the whole crop may be severely affected.

At a later stage the colour of the pustules changes to blackish-brown due to the production of spores of a different kind (teleutospores). These dark spores are thick walled resting spores which serve to carry the fungus over the winter months. The following spring the teleutospores germinate and with suitable conditions they cause new infections which lead to the appearance once more of the uredospore stage.

CLIMATIC CONDITIONS.

The development of diseases of this kind is greatly influenced by the weather, and this relationship is seldom fully appreciated. Some are capable of thriving under any conditions which favour the growth of the host plant but fortunately the development of many others including bean rust is restricted by a range of climatic requirements much narrower than that of the plant attacked. — Thus diseases such as bean rust may linger almost unnoticed for several years, when their development is restricted by unsuitable weather, but in a season bringing climatic conditions which favour them, they may quickly multiply and reach epidemic proportions. During February the weather was unusually cool and muggy, which conditions are extremely favourable for this disease. In normal years, however, it would appear that similar conditions are not likely to be encountered until later in the season, by which time all except late crops will have been harvested.

CONTROL.

Resistant Varieties:

Bean rust is best controlled by growing resistant varieties. In Western Australia the "white-seeded runner bean," sold commercially under various names, including Prolific, Abundance, and Golden Harvest, has practically superseded all other runner bean types, owing to its high resistance to bacterial blight.

Accordingly observations of varietal reactions to the disease have been limited, but in general, french bean types, including the Vincent variety which is fairly resistant to bacterial blight also, showed greater resistance than runner beans.

Owing to the occurrence of races of the bean rust parasite, each of which may attack different varieties, it does not follow that a variety will maintain its resistance in all localities. If the disease proves to be troublesome in future years it will be necessary to test varieties locally.

Fungicides.

The application of fungicides to control the disease is worthy of trial under our conditions. Lime sulphur 1-80 to 1-100, or a dust containing equal parts of sulphur and air-slaked lime, are recommended for this purpose. Both these fungicides will help to control red spider, which is troublesome in bean crops during the summer months. Either spray or dust should be applied immediately the disease is noticed, and thereafter at weekly intervals unless unfavourable weather checks the disease.

Hygiene.

After harvesting is completed all crop remains should be removed and destroyed to reduce the infection of later sown crops, and to prevent as far as possible the carry-over of the disease through the winter months.

In pre-war days this practice was general, but since the war it has been largely neglected owing to various difficulties.

The Influence of Topdressing with Copper Sulphate on the Copper Content and the Yield of Mixed Pasture at Gingin.

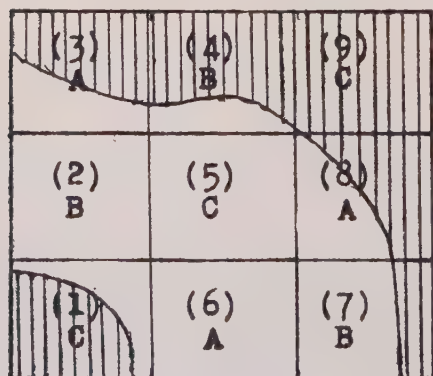
E. J. UNDERWOOD, T. J. ROBINSON, and D. H. CURNOW.

It has been shown that the disease "Gingin Rickets" or "enzootic ataxia" of lambs is due to a copper deficiency (Bennetts and Chapman, 1937; Bennetts and Beck, 1942). This disease can be prevented by the administration of suitable copper containing licks to the mother and there is now ample evidence that the benefits of such licks are not confined to the prevention of ataxia. Optimal growth in lambs and a marked beneficial effect on the health and the wool quality of the adult are obtained. There is also evidence that the topdressing of pastures with copper compounds in the affected areas will raise the copper content of the pasture to "normal" levels and thus bring about the same results. In fact there is a strong suggestion that the treatment of pastures is the better method of the two. There is a marked absence of information, however, as to the optimal rate or rates of copper topdressing for this purpose, or of the period of effectiveness and the effect on yield if any. It was decided therefore to carry out an experiment to provide data on these points as a guide to future more detailed studies. The results are described below, together with some studies of species differences in copper content.

Some experimental information on this problem has become increasingly important as more and more evidence accumulates that areas copper deficient both for stock and for the growth of crops, are much more widespread in W.A. than was supposed when the first investigations were being made. The results of experiments in one area will not necessarily apply to others since the nature of the response to treatment with copper depends very significantly on such factors as the soil type and the plant species grown. The Gingin district seemed a good place for an experiment since considerable information on copper deficiency in stock was already available and in addition a soil survey of the area had been carried out. (Hosking and Greaves, 1936).

LOCATION AND LAYOUT OF EXPERIMENT.

An area of pasture on the Wedge Estate at Gingin was chosen. The area is made up partly of "Whakea sand" which is a predominant soil type in this district and partly of "Minjil sand." The distribution of these two types of soil in the experimental area is shown on the plan below.* An area $4\frac{1}{2} \times 4\frac{1}{2}$ chains was

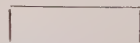


A—Controls—No copper.

B—7.5 lbs. copper sulphate per acre.

C—15 lbs. copper sulphate per acre.

"Whakea" sand



"Minjil" sand



*We are indebted to Dr. L. J. H. Teakle, Plant Nutrition Officer, for this classification.

fenced and divided up into nine plots $1\frac{1}{2} \times 1\frac{1}{2}$ chains in size in the form of a 3 x 3 Latin square, as shown on previous page.

In April, 1939, shortly after germination of the pasture species treatment was given to the plots as follows:—A plots, superphosphate only at the rate of 30 lbs. per acre; B plots, superphosphate at the same rate plus copper sulphate at the rate of 7.5 lbs. per acre; C plots, superphosphate at the same rate plus 15 lbs. copper sulphate per acre. The copper sulphate was mixed with the superphosphate and spread by hand on each plot divided into four to ensure even distribution. No further treatment with copper was given, but in the early autumn of the following two years, 1940 and 1941, all the plots were topdressed with 90 lbs. superphosphate per acre.

Sampling was carried out four times in each year on approximately the same dates by clipping five random yard squares from each plot. The samples from these were oven-dried and weighed separately for the estimation of dry weight yields and kept for chemical analysis. The times of cutting in each year were as follows:—

First cut; mid-June—Short young green growth.

Second cut; mid-August—Well-grown green growth, before flowering.

Third cut; mid-September—Fully-grown, flowering, partially mature.

Fourth cut; end-October—Mature, dry.

After each sampling a very large number of sheep were grazed on the plots in order to eat the pasture right down within a few days. It is important to note that the sum of the yields represents therefore the total yield of herbage available in each year from this type of grazing and the copper content of the successive samplings allow estimates of the seasonal copper intakes of grazing animals to be made.

At the beginning of the experiment all the plots were sown with wimmera rye grass and subterranean clover, each at the rate of 4 lbs. seed per acre. The seed was distributed by hand on the surface after light scarifying. Neither of these species contributed greatly to the bulk of herbage produced in the first year, although the proportion, particularly of Wimmera rye grass, was very much greater in 1940 and 1941. In 1939 the main pasture species was capeweed (*Cryptostemma calendulaceum*) with such poor annual species as silver grass (*Festuca* spp.) various brome grasses (*Bromus* spp.), barley grass (*Hordeum murinum*), cluster clover (*T. glomeratum*), woolly clover (*T. tomentosum*) and some subterranean clover (*T. subterraneum*). The capeweed, although forming a considerable proportion of the pasture was not nearly so dominant in the two following years.

RESULTS.

Pasture Yields.

The yields were obtained by averaging the five yard squares on each plot and taking the mean of the three plots of each treatment. The results, calculated as cwt. of dry material per acre, are given for the three years of the experiment in Table 1.

The most noticeable thing about Table 1 is the very great increase in total yield in 1940 and 1941 compared with 1939. This was in spite of the fact that 1939 was a very good season with a total rainfall incidence between April-October of 31.8 inches, whereas in 1940 the rainfall during the same period was only 15.5 inches. In 1941 it was 27.6 inches. Undoubtedly the dominant reason for this was the development of more productive species, particularly Wimmera rye grass, and to a lesser extent subterranean clover in the second and third year. These did

not grow well in the year in which they were sown. The heavier dressings of super-phosphate in these two years, compared with the small dressing in 1939, perhaps contributed to this development, although the regular system of heavy rotational grazing may also have been important. Controlled experimental evidence on the influence of these factors is needed.

TABLE I.
PASTURE YIELDS.
Cwts. per acre of dry material.

Treatment.	Year.	Mid-June.	Mid-Aug.	Mid-Sept.	Late Oct.	Total.
No copper	1939	Samples taken but not weighed	4.2	4.0	6.0	14.2
Copper Sulphate—7.5 lbs. per acre	"		4.2	4.3	5.2	13.7
Copper Sulphate—15 lbs. per acre	"		4.1	3.9	6.4	14.4
No copper	1940	0.6	10.0	15.5	20.0	46.1
Copper Sulphate—7.5 lbs. per acre	"	0.7	12.0	12.0	18.0	42.7
Copper Sulphate—15 lbs. per acre	"	0.6	10.0	10.0	13.6	34.7
No copper	1941	5.9	14.5	17.5	18.6	56.5
Copper Sulphate—7.5 lbs. per acre	"	6.5	14.8	18.4	17.2	56.9
Copper Sulphate—15 lbs. per acre	"	5.6	13.4	12.6	14.0	45.6

In 1939 no difference in average yield between the copper treated and the untreated plots was evident, either in the total for the year or at any stage of the season. The same is true for the early part of the following two seasons. Thereafter, there was an apparent decrease in total yield in the copper treated plots in both 1940 and 1941, particularly in the plots receiving the heavier dressing (15 lbs. copper sulphate per acre). This effect was more noticeable in the final sampling in 1940 than in 1941. Statistical treatment of the individual cuts, however, revealed that this difference is not significant. It is due to the great variability of the individual cuts and also to the very poor growth on one of the "C" plots (receiving 15 lbs. of copper sulphate per acre), namely, plot 1. It will be noted that more than half of this plot consists of "Minjil" sand. The poor yield cannot be attributed to this fact alone, however, as plot 9, also a "C" plot, consists entirely of "Minjil" sand, and yielded as well as the surrounding plots, including number 5. In fact the individual plot yields show no correlation with soil type differences.

It is evident that with pasture of such variability as that on which this experiment was carried out many more replications and a different design is necessary if small differences in yield, due either to a beneficial or a deleterious effect of the copper dressings, are to be revealed. Nevertheless, the absence of any reduction in yield in the copper treated plots in the first year, when the copper was put on, makes it appear very unlikely that a dressing of 15 lbs. of copper sulphate is toxic on such soils with the particular plant species present. It has, however, been shown by Teakle (1941, 1942) that applications of copper sulphate at rates in excess of 10-15 lbs. per acre depress yields on some Western Australian soils.

COPPER CONTENT OF PASTURES.

The copper content of the pastures was determined by a method based on that of Sylvester and Lampitt (1935). In 1939 analyses were carried out on each separate yard square, that is, on five samples from each plot or 45 samples at

each cutting. In the two following years the aliquots of the five cuttings from each plot were taken after drying and grinding, and analysis of the mixture of these aliquots carried out. The mean figures for the copper content of the mixed pasture from each treatment set out in Table 2 represent the average of 15 separate analyses (five from each of three plots) in each case in 1939. In 1940 and 1941 these figures represent the average of three separate analyses only, although the three samples analysed were, as explained above, a mixture of five separate quadrats. The results are expressed as parts per million on the dry basis.

In the first year, when the copper was applied, the top-dressing with bluestone, at both the lower and higher rates, has been very effective in raising the copper content of the herbage to adequate values. This effect is highly significant for the season as a whole (at the $P = .01$ level) and is equally so during the following year, 1940. In 1941, the third season following treatment, there is still a significant effect from the higher level of treatment and the copper content of this herbage can be regarded as easily adequate for the requirements of grazing stock. An increase in copper content from the lower level of treatment has also been maintained into the third season, but the effect is less marked. In fact it is barely significant by the same statistical tests and the mean value for the season is hardly high enough to provide a really satisfactory copper intake for grazing animals. Most Western Australian pastures from "sound" areas known to be healthy for stock contain 7-14 ppm. of copper, but present evidence indicates that a level of 6 ppm. can be regarded as adequate.

TABLE 2.
COPPER CONTENT OF PASTURES.
ppm. Cu on dry basis.

Treatment.	Year.	Mid-June.	Mid-Aug.	Mid-Sept.	Late Oct.	Mean.
No copper	1939	not analysed	5.4	5.0	5.0	5.1
Copper sulphate—7.5 lbs. per acre	"		8.4	8.5	6.5	7.8
Copper sulphate—15 lbs. per acre	"		9.8	11.0	8.8	9.9
No copper	1940	5.3	3.8	4.3	3.7	4.3
Copper sulphate—7.5 lbs. per acre	"	10.3	5.9	7.2	4.5	7.0
Copper sulphate—15 lbs. per acre	"	11.4	6.0	8.9	6.4	8.2
No copper	1941	2.6	4.4	3.3	not analysed	3.4
Copper sulphate—7.5 lbs. per acre	"	4.3	5.2	5.9		5.1
Copper sulphate—15 lbs. per acre	"	5.3	6.7	9.1		7.0

The only comparable figures from mixed pasture are those given by Bennetts and Beek (1942). These workers found that treatment of similar pasture at Gingin with 20 lbs. copper sulphate per acre raised the copper content from the 3.4 ppm. of adjacent areas to 10-15 ppm. in the year of treatment. This remained at 10-11 ppm. in the growing period of the following year and one sample taken in the third year showed a value of 7.6 ppm. on the dry basis. This compares particularly well with the result from the treatment with 15 lbs. per acre in the present experiment.

A very interesting aspect of Table 2 is the variation in copper content of the untreated plots in the three years of experiment. It will be seen that there is a small but consistent fall from 1939 to 1941. In 1939 the values are higher than would be expected from the work of Bennetts and Beek (1942) on other

Gingin pastures taken in the same and in previous years. In the two following years the values, although lower, are still not quite as low as those of Bennetts and Beck. The higher values in 1939 may have been influenced by the greater proportion of capeweed in the pastures in this year since, as will be shown later, this species carries under some conditions a higher copper content than other species growing with it, such as subterranean clover and Wimmera rye grass. The possibility that differences in the seasonal conditions have significantly affected the copper content must also be taken into account. As in the case of the yield figures there is no correlation between the copper content of the individual plots and the distribution of the two soil types on the experimental area. In other words it can be stated that within the limits of the present experiment "Whakea" sand and "Minjil" sand show an equal evidence of copper deficiency.

A decided improvement in the health of grazing stock in the late spring in copper deficient areas is well known. This would imply a higher copper content of the pasture at this time, but the data of Table 2 do not support this. In fact the values for mixed pastures tend to be lower at this time of the year when the pastures are mature. A similar finding with mixed pasture was made by Beck (1941). At other times of the year there do not seem to be any consistent differences in copper content which can be correlated with stage of growth. It should be stressed that in the present experiment the grazing conditions were strictly controlled. After each sampling the pasture was grazed almost bare within a few days and then left ungrazed until the next sampling period.

COPPER CONTENT OF DIFFERENT PLANT SPECIES.

Ample evidence is available from other work in W.A. and elsewhere that different plant species vary considerably in their copper content when growing under the same conditions and absorb copper differently from varying soil types. Accordingly, it was necessary to obtain some information as to the copper content of the main species in the pasture under investigation. All of the above analyses, as explained earlier, are of mixed pasture samples, since the primary object was to measure the ability of the pasture as a whole, under the different treatments, to supply copper to grazing stock. To have obtained this information, together with a measure of the contribution of the different species making up the pasture, would have involved a tremendous amount of extra work in separation, weighing and analysis. A series of samples of subterranean clover, Wimmera rye grass, and capeweed, growing together, were therefore taken, both from the Gingin plots and from pasture very recently laid down on a podsolised sand at Perth. The results are presented in Table 3.

It is seen that subterranean clover and wimmera rye grass are very similar in copper content, both at Gingin and Perth. Capeweed, on the other hand, is consistently higher at Perth and in the later cuts at Gingin. An August, 1941, at Gingin the three species show little difference between each other at either of the levels of treatment with copper. Apparently capeweed absorbs copper more readily from some soils than do certain other pasture species. This has already been suggested from some rather limited evidence in other parts of W.A. (Teakle *et al*, 1941 and Beck, 1941) and in New South Wales (Aust. Wool Board Report, 1940). It should be made clear, however, that under some conditions capeweed analyses can be a very valuable indicator of copper deficiency. Very low copper values for capeweed have been found recently by Bennetts and Underwood (1942, unpublished data) from certain areas where copper deficiency symptoms in sheep have been demonstrated.

TABLE 3.
COPPER CONTENT OF DIFFERENT PLANT SPECIES.

ppm. Cu on dry basis.

Source.	Date.	Sub- terranean Clover.	Wimmera Rye Grass.	Capeweed.
Gingin "Whakea sand"—No added copper	15-8-41	3.4	4.0	3.3
Gingin "Whakea sand"—Copper sulphate, 7.5 lbs. per acre	"	6.7	8.0	5.3
Gingin "Whakea sand"—Copper sulphate, 15 lbs. per acre	"	9.0	8.7	9.0
Gingin "Whakea sand"—No added copper	15-9-41	3.1	3.0	5.0
Gingin "Whakea sand"—Copper Sulphate, 7.5 lbs. per acre	"	7.1	5.2	10.2
Gingin "Whakea sand"—Copper sulphate, 15 lbs. per acre	"	8.4	5.7	13.6
Perth sand—no copper added	24-9-40	3.5	2.8	6.4
Perth sand—no copper added	29-7-41	5.5	6.3	7.3
Perth sand—no copper added	1-9-41	4.2	3.9	5.8
Perth sand—no copper added	5-8-42	4.9	4.1	9.7
Mean	...	5.6	5.2	7.6

DISCUSSION.

Although no improvement in yield of pasture was obtained from the copper treatment, a similar lack of response should not be assumed in other areas where copper deficiency in stock is known to exist or even with other crops in the same area. Thus Teakle *et al* (1941) have obtained an increase of oaten grain on "Wakhea sand" at Gingin and observed some of the symptoms of copper deficiency in the growing oat crops. It is the experience of farmers in the district that crops of oaten hay are improved by the use of copper containing fertilisers. There is also some evidence of improvement in pastures in certain parts of the Gingin district, although experimental data on this point is so far lacking. It is expected that experiments now being carried out by the Plant Nutrition Branch of the Department of Agriculture will go some way towards providing the necessary evidence.

The pronounced effect of the copper treatments on the copper content of the herbage without any corresponding effect on yield, is a matter of considerable practical significance. It is important to realise that a copper deficient soil can affect pastures by lowering yield; by altering the botanical composition; by producing herbage of lower copper content, or by one or all of these effects. Under certain conditions, a lower copper content may be the only result of the deficiency. This deficiency may not affect pasture growth and appearance, but may reduce the copper content of the herbage to such an extent that it is below the requirements of grazing stock.

The Gingin district, although definitely copper deficient, is not so severely deficient as parts of the Busselton-Margaret River area for instance, where even lower pasture copper levels consistently occur (Bennets, *et al* 1941, Beck 1941), and where yield and botanical composition are also affected. At Gingin, judging by the results of the present experiments, the copper status is such that the common pasture species maintain their yield but with a lower copper content than

similar species in more favoured areas. With a more severe deficiency or with the introduction of pasture species with a higher copper requirement, yield as well as copper content is likely to be affected.

It is apparent that there is a considerable residual effect from the copper sulphate treatments. In the case of the 15 lbs. per acre level this has been sufficient to maintain satisfactory copper values in the herbage into the third season following treatment, while even with half this level there has been a small but significant raising of the copper content in the third year. In practice therefore it is not only unnecessary to topdress with copper every year, but it seems highly probable that rates of application below those used in this experiment would, over a period of years, be perfectly satisfactory. Definite recommendations on this important matter must await the results of further experiments, some of which, as pointed out previously, are already being undertaken by the Department of Agriculture.

SUMMARY.

An experiment was carried out to determine the effect on the yield and copper content of mixed pasture, in an area at Gingin copper deficient for stock, of topdressing with copper sulphate at levels of 7.5 lbs. and 15 lbs. per acre.

No significant effect on the yield of pasture was obtained from either of the treatments.

A marked effect in raising the copper content of the pasture was given by both levels of topdressing. For three seasons following treatment the heavier dressing maintained the copper content of the pasture at a level known to be adequate for the health of grazing stock. The lighter dressing maintained satisfactory levels for two seasons, and some improvement in copper content was still noticeable in the third year.

It is concluded that treatment with 15 lbs. copper sulphate per acre every third year or half that quantity every second year is more than ample to maintain the copper content of pasture on similar soils in such areas at an adequate level for grazing stock. Over a period of years it is probable that much smaller quantities would be quite satisfactory. Evidence on this point is now being obtained.

No significant differences in copper content were found between subterranean clover and Wimmera rye grass growing under the same conditions and at approximately the same growth stages. In one area capeweed was found to be consistently higher in copper content than either of these two species.

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Grateful acknowledgment is made to Mr. F. Wedge for placing land and material on the Wedge Estate at Gingin at our disposal; to Dr. H. W. Bennetts for his interest and assistance throughout; and to the Agrostology Section of the C.S. & I.R. in W.A., for their valuable aid in the collection and drying of the samples.

Butter Boxes.**The Effect of Western Australian Timbers on the Flavour of the Surface of the Butter.**

M. CULLITY, Superintendent of Dairying.

In Western Australia butter intended for export or for storage under the Dairy Products Marketing Scheme is packed in hoop-pine boxes which have been sprayed with a casein-formalin mixture evolved by Dr. J. Wiley of the Council for Scientific and Industrial Research.

During 1942, owing to various difficulties, a shortage of hoop-pine boxes occurred and although supplies were eventually received, in which the bulk of the State's surplus butter was packed, portion of the surplus was stored in boxes made from a variety of timbers. Much of this butter acquired a strong surface wood taint.

It was feared that a further, more serious shortage might occur and consideration was given to the possibility of procuring supplies of boxes made from the most suitable local timbers.

As it was possible that butter might remain stored in local timbers for long periods, or in certain circumstances be exported, it was decided at a Conference of representatives of the Institute of Dairy Factory Managers, the Forestry Department and the Department of Agriculture, that trial boxes of various timbers be made and sprayed with the casein-formalin mixture.

The degree of taint on the surface of the butter packed in these boxes was to be compared with that on butter packed in unsprayed boxes of the same timbers. Seasoned mature karri, young karri, jarrah and blackbutt, having less than 15 per cent. moisture, were selected for the trial.

Twelve boxes of each were made by Mr. F. Simper at the Safety Box Company Factory, Fremantle.

The preparation used for spraying was:—Water, 5 parts; casein, 1 part; caustic soda, 1/16th part.

The formalin solution was diluted 1 : 7 with water. Spraying was carried out, using pumps removed from knapsack spray outfits.

Some difficulty was experienced in obtaining an even coating of the interior surface of the boxes which were already made up, but examination later showed that this had not proved a serious defect.

On the same day three black-butt boxes were sprayed on the flat—that is, before being made into boxes—and it was found that spraying could be carried out much more easily and rapidly.

The boxes were forwarded to the South-West Co-operative Dairy Farmers' Bunbury factory, where they were packed with butter on the 25th September and returned to Perth, where they were held in store at the Sunny-West Dairies.

Sample boxes of each timber were examined on the 9th, 16th, 23rd and 30th October, 1942, and the 21st January, 1943, the last series having been in store for almost four months.

It was apparent beyond any doubt that the black-butt timber which it had been suggested might be suitable, was extremely disappointing as the butter paper and the butter were badly stained and tainted.

The boxes made from karri were far superior to the black-butt, but some small degree of taint was discernible on the surface of the butter. This applied to both the mature and the young karri. While the taint was discernible, it was considered not so pronounced as that imparted to butter from hemlock and spruce.

Jarrah was still more successful: butter in the unsprayed boxes had less taint than those packed in the other untreated timbers and was superior to that in the sprayed black-butt boxes. In only one box did the taint from jarrah appear to be more than that from karri.

Examination of the butter from the sprayed jarrah boxes was particularly pleasing inasmuch as no discoloration of the lining papers, nor wood taint on the surface of the butter, could be detected. These boxes were definitely superior to the others used in the trial.

It was the unanimous opinion of those present at the examination of the butter, that it could not have opened up any better if it had been packed in sprayed hoop-pine boxes.

It should be explained, however, that for the purpose of the trial the box manufacturer was asked to procure jarrah cut from a young tree. In order to comply with this request at short notice, the boxes were cut from a telegraph pole which had been in use for 15 years. Accordingly the results obtained could not be considered completely reliable as an index to the effect of newly-seasoned young timber. One series of boxes was held in the ante room for a week to encourage the sweating of the butter, in order to ascertain whether greater staining would occur. No additional damage was noted.

After the examination of the butter on the 30th October, it was decided that a further trial should be commenced using new timber from mature jarrah trees. Again reliance had to be placed on the manager of the box factory to procure suitable logs.

Three sets of eight boxes each were manufactured from:—

- (1) green timber;
- (2) semi-dry timber—25% moisture;
- (3) dry timber—under 16% moisture.

The timber was darker in colour (red) than in the first series of boxes and to that extent confirmed the greater maturity of the timber.

The boxes were made on the 6th November and four of each group were sprayed immediately.

These boxes were packed with butter at the South-West Co-operative Dairy Farmers' factory at Bunbury on the 13th November, and after storage were examined on the following dates: 18th December and 21st January.

The comments made were of the same order on each inspection and are as under:—

- | | | |
|-------------------------------|----|--|
| (1) Green jarrah—unsprayed | .. | strong wood taint. |
| Green jarrah—sprayed | .. | very strong wood taint—boxes warped and timber shrunk. |
| (2) Semi-dry jarrah—unsprayed | .. | easily detectable wood taint. |
| Semi-dry jarrah—sprayed | .. | very faint taint. |
| (3) Dry jarrah—unsprayed | .. | faint taint. |
| Dry jarrah—sprayed | .. | no taint. |

In all unsprayed boxes slight staining of the paper was noticeable, while in the sprayed boxes the papers were slightly stained at the junction of the boards.

The result of these trials may be summarised as showing that the jarrah which had been seasoned and sprayed with the casein-formalin mixture did not taint the butter.

In the possible event of emergency, therefore, in which normal supplies of the approved type export boxes were unavailable, seasoned jarrah sprayed could be used with some confidence that the butter would not deteriorate unduly because of timber taint.

As a result it was suggested to the manufacturers of butter that they should protect themselves and the industry, by making suitable arrangements so that seasoned jarrah boxes would be available if needed. It should need no emphasis to indicate that unless preparations are made well before any emergency could arise, it might prove difficult at short notice to get jarrah dry enough to avoid tainting of the butter.

To pursue this matter further, it is hoped to arrange a small shipment for export so that a report may be procured from London.

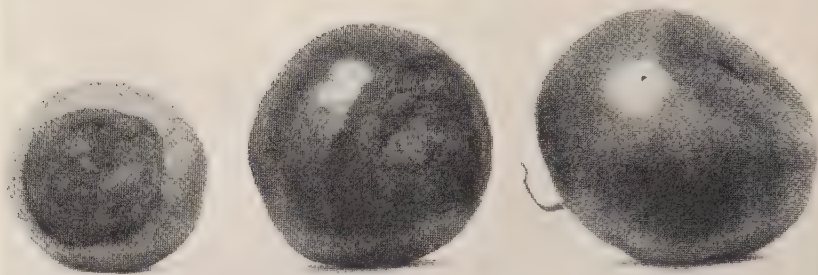
It is pointed out that while some jarrah boxes are used successfully in the local trade, no attempt has been made in this trial to compare timbers on any basis other than their capacity to transmit taint to butter. For example, jarrah has not been compared with other timbers on the basis of its weight, colour, ease of handling, ease of wiring, its inclination to shrink and expand, or its re-use value.

Blossom-End Rot of Tomatoes.

W. P. CASS SMITH, Plant Pathologist.

During the summer months many tomato specimens were received showing symptoms of blossom-end rot; in most cases the growers concerned attributed the trouble to parasitic causes and were anxious to prevent it spreading. However, blossom-end rot is a non-parasitic trouble, in the development of which soil and climate play an important part, and it cannot be controlled by sprays.

While the exact relationship of environmental and genetic factors to the occurrence of the disease is not completely understood, it is generally accepted that the ultimate cause of blossom-end rot is a deficiency of water at about the time the fruit is ripening. When water becomes deficient the fruit cannot compete with the rest of the plant for it, and thus the cells of the fruit furthest from the water supply, i.e., at the blossom-end, collapse and die.



Blossom-end rot of tomatoes.

[After Carne.]

It is, therefore, understandable why blossom-end rot is prevalent when the soil becomes too dry, but because the disease is also prevalent at times when the soil is wet, growers are sometimes not readily persuaded that water deficiency is the cause.

Plants require large quantities of moisture from the soil for their growth especially during the summer months; but the amounts retained and combined with food materials to make new plant tissues are very small. The surplus water is drawn from the foliage into the air, the amount lost being regulated by such factors as air temperature, humidity, wind and type of plant.

On hot summer days, especially when strong drying winds prevail, the amount of water lost from the foliage may increase enormously. When this occurs the roots even in *wet soil* may be incapable of supplying water fast enough to balance the rate of water loss and the plant becomes "stressed" for moisture. If "stressing" is too prolonged portions of the plant commence to wither and withering continues until the water balance is restored.

As already explained, when ripening fruit is present on the tomato vine, withering commences in the cells at the blossom-end; and it becomes obvious by the appearance of a putty coloured to dark brown, or blackish rot (see Plate). The rotted area may be small or it may extend over half the total surface of the fruit, and if it is invaded by secondary organisms the whole fruit ultimately decays. Under the conditions prevailing in this State, this type of water deficiency, induced by hot drying winds appears to be the commonest cause of blossom-end rot; the disease is also prevalent when the soil is allowed to become too dry following a plentiful water supply as, e.g., when tomatoes are grown under sprinklers, or irrigated.

As the disease is largely caused by climatic factors, control is difficult. Nevertheless it may be reduced considerably by attending to the following points:—

Increase the water-holding capacity of the soil and the size of the root system by the incorporation of humus forming materials and by applications of superphosphate and potash manures. Reduce water loss from the foliage:—by applying the smallest necessary amounts of nitrogenous manures such as poultry manure, blood and bone, sulphate of ammonia, etc., which encourage succulent leaf formation—by the use of sprinklers during heat waves to increase atmospheric humidity

and keep the soil moist—and by the employment, where practicable, of wind breaks. In general it has been found that nitrogenous manures tend to increase blossom-end rot, whereas potash manures have a reverse effect, and that plants watered with amounts sufficient for healthy growth are more resistant than those over-watered or watered irregularly.

Wheat and Oat Variety Trials, 1942.

I. THOMAS, Superintendent of Wheat Farming, and
A. J. MILLINGTON, Field Technician.

WHEAT.

Wheat variety trials were conducted during 1942 at the five widely distributed Research Stations and also, under departmental supervision, on two private farms.

Details of the monthly rainfall at the research stations are as below, together with the average over the period since each station's inception.

Year.	Jan.	Feb.	Mar.	Growing Period.						Total.	Nov.	Dec.	Total for Year.	
				Apr.	May.	June.	July.	Aug.	Sept.					Oct.
AVONDALE RESEARCH STATION.														
1942	7	8	153	80	161	276	266	277	105	46	1,131		186	1,565
Av., 16 years ...	27	42	111	84	229	299	303	238	105	93	1,266	46	38	1,615
CHAPMAN RESEARCH STATION.														
1942	24		23	209	403	428	242	227	136	91	1,527			1,783
Av., 37 years ...	27	38	69	73	238	422	384	269	151	91	1,555	36	26	1,825
MERREDIN RESEARCH STATION.														
1942	37	8	132	106	205	181	169	169	76	40	840	24	317	1,464
Av., 31 years ...	46	51	96	86	133	187	179	147	86	81	807	43	62	1,193
SALMON GUMS RESEARCH STATION.														
1942	36	104	595	177	121	134	139	220	92	255	961	5	188	2,066
Av., 17 years ...	104	63	148	91	129	141	142	158	89	126	787	95	74	1,362
WONGAN HILLS RESEARCH STATION.														
1942	28		491	91	428	191	173	243	153	45	1,233	5	85	1,933
Av., 17 years ...	36	47	104	92	192	246	255	196	94	77	1,060	44	48	1,429

The actual monthly totals do not give a true picture of the seasonal conditions as from May to August there were periods when rain was practically a daily occurrence, the effect being most severe at Chapman and least at Avondale and Salmon Gums. Details regarding growing conditions at the Research Stations can be briefly summarised as follows:—

Avondale.—Despite rather difficult periods during seeding operations, seasonal conditions were generally satisfactory for both crops and pasture. Crop yields reflect the conditions as also did the stock, the growth rate of the lambs being higher than the previous year.

Chapman.—As far as the grain crops were concerned, the season was a failure, excessive and continuous rains negated any weed control resulting in choked out crops and very low yields. Pasture growth was, however, excellent, particularly with the sown pastures. The pasture conditions were reflected by the excellent condition of all stock throughout the season.

Merredin.—Early seasonal conditions were quite good, though the rather persistent rains increased weed growth during planting. Portion of the crop was, as a result, planted later than desirable. The lack of finishing rains reduced the yields of the early sown crops and seriously affected the late sown crops. The Bungulla planted in May yielded approximately 23 bushels, whereas that planted in late June, yielded 10 bushels per acre. Pasture growth was satisfactory with an excellent wool clip.

Salmon Gums.—One of the most satisfactory seasons for many years was experienced; crop and pasture growth was excellent, record yields were not obtained, but results were affected particularly for the oats, by storm damage. Pasture growth, especially the wimmera rye grass was excellent and an excellent wool clip was obtained.

Wongan Hills.—During the early part of the growing period conditions were very wet and cold, making seeding operations difficult and retarding growth. Conditions improved somewhat during the latter part, but lack of finishing rains affected the yields which, however, must be considered satisfactory under the circumstances.

Under the diversity of conditions encountered, Bencubbin yielded consistently and remains the most prolific variety under test.

The objective of the departmental breeding programme, therefore, is to produce new varieties which, whilst they retain the yielding ability of Bencubbin, are superior in respect to rust resistance and straw strength. Some success in the direction of this objective has been achieved in the varieties Koorda and Kondut which were released for general cultivation during 1942-43. Both Kondut and Koorda closely approach Bencubbin in yielding ability and have much stronger straw.

The variety Kondut is slightly later maturing than Bencubbin and in view of its excellent straw strength, it is an ideal variety for early plantings, principally in the higher and more favoured rainfall districts and can be considered particularly suited for light land in such districts. Under suitable conditions, Kondut yields flour of almost premium strength.

For later plantings, Koorda has been bred as a suitable alternative to Gluyas Early, Totadgin and Merredin. Notable for its stout, strong, straw, Koorda can be considered the early maturing counterpart to Kondut.

Situated in an area of occasional rust epidemics, the Chapman Research Station is of value as a site for testing varieties resistant to this disease.

Over a five-year period, the rust resistant variety Fedweb has consistently outyielded Nabawa by a small margin. The rather late maturity of Fedweb has resulted in its cultivation being restricted to the wetter and most favourable wheat growing localities.

The very rust-resistant Eureka varieties were tested in 1941 and again in 1942. Eureka 1 is early maturing, but sheds rather too freely to have wide acceptance as a variety. The mid-season maturing, Eureka II, holds its grain well and has yielded satisfactorily in extensive yield trials.

The Waite Institute variety Warigo was under test for the first time in 1942. Although inclined to be weak strawed, Warigo yielded fairly satisfactorily, having due regard to the most unfavourable growing conditions. In view of its resistance to rust, it will be included in further trials.

Details of the yields obtained are set out in the accompanying tables.

WHEAT VARIETY TRIALS CONDUCTED ON RESEARCH STATIONS, 1942.

Maturity.	Variety.	CHAPMAN RESEARCH STATION.				AVONDALE RESEARCH STATION.				SALMON GUMS RESEARCH STATION.			
		1942 Season.			Average. Over Period Percentage (Years in brackets).	1942 Season.			Average. Over Period Percentage (Years in brackets).	1942 Season.			Average. Over Period Percentage (Years in brackets).
		Varietal Yield per Acre.	Yield per Acre adjacent Nabawa Control.	Percentage of Control.		Varietal Yield per Acre.	Yield per Acre adjacent Bencubbin Control.	Percentage of Control.		Varietal Yield per Acre.	Yield per Acre adjacent Nabawa Control.	Percentage of Control.	
Late	Fedweb Kondut	bus. lb. 9 31 9 43	bus. lb. 8 31 9 19	% 112 104	% 105 (5) 107 (5)	bus. lb. 17 20 24 42	bus. lb. 25 0 24 22	% 69 101	% 76 (2) 95 (2)	bus. lb. 28 6 28 4	bus. lb. 27 34 28 28	% 102 99	% 97 (3) 96 (3)
Mid-Season	Bencubbin Eureka II. Ford Nabawa Warigo	10 46 5 55 7 59 9 14	9 19 7 0 Control 8 31	115 85 114 108	117 (6) 106 (2) 102 (6) 108 (1)	19 48 22 12	25 0 24 22	Control 79		31 50 27 40	28 28 27 34 Control	112 100	113 (3) 100 (1) 90 (2)
Early	Eureka I. Guysa Early Koorda Merredin	10 18 9 6 8 50	10 2 11 15 11 15	103 81 78	103 (2) 108 (5) 97 (4)	23 18 18 54 21 18	25 45 26 57 26 57	90 70 79		25 10 30 40	26 28 26 28	 95 116	96 (2) 108 (3) 97 (2)
Very Early	Bungulla Noongaar	11 4	10 2	110	113 (4)	27 30	25 45	107	102 (2)	28 16 23 2	26 18 26 18	107 88	106 (3) 88 (1)
		Planted Germinated	15th May. 20th May. Bencubbin Eureka II. Fedweb Kondut Ford Warigo	4th June. 11th June. Eureka I. Koorda Merredin Bungulla	25th May. 4th June. Merredin Koorda Bungulla Eureka I.	Planted Germinated	5th May. 25th May. Eureka II. Fedweb Kondut Ford		25th May. 4th June. Merredin Koorda Bungulla Eureka I.	Planted Germinated	15th May. 20th May. Bencubbin Eureka II. Fedweb Kondut Noongaar		30th May. 7th June. Bungulla Guysa Early Koorda Noongaar

WHEAT VARIETY TRIALS CONDUCTED ON RESEARCH STATIONS, 1942—continued.

Maturity.	Variety.	MERREDIN RESEARCH STATION.						WONGAN HILLS RESEARCH STATION					
		1942 Season.			Average for Period.			1942 Season.			Average for Period.		
		Varietal Yield per Acre.	Yield adjacent Bencubbin Control.	Percentage Control.	1941-42 Bencubbin Control.	Ending 1939 Nabawa Control. *	%	Varietal Yield per Acre.	Yield adjacent Bencubbin Control.	Percentage Control.	1941-42 Bencubbin Control.	Ending 1940 Nabawa Control. *	%
Late	Kondut	25 26	27 46	92	91	74 (3) April	...	...	...	...	86 (1941)	113 (2) April	113
	Sutton	...	...	...	...	77 (6) April	...	...	...	...	76 (1941)	109 (3) May	108
	Yandilla King	...	...	...	...	73 (1) April	...	...	...	...	66 (1941)	102 (9) April	97
	Fedweb	...	...	...	...	77 (1) April	...	...	...	...	...	92 (9) May	92
Mid-Season	Bencubbin	...	Control	...	...	113 (10) April	...	Control	...	...	...	112 (10) April	112
	Nabawa	...	...	...	90 (1)	112 (10) May	...	...	...	...	74 (1941)	112 (10) May	112
	Ford	...	...	...	81 (1)	117 (9) June	...	...	...	...	...	105 (10) June	105
	Eureka II.	22 35	27 46	81	...	80 (1) April	...	...	...	...	...	92 (2) April	92
Early	Glyvas Early	21 34	25 20	85	77	82 (4) April	...	...	...	...	81 (1941)	95 (9) April	95
	Merredin	...	...	...	...	108 (11) May	...	...	...	...	...	95 (10) May	95
	Totadgin	...	...	...	...	112 (10) June	...	15 4	21 4	72	81	98 (10) June	98
	Koorda	20 3	25 20	79	81	101 (9) June	...	...	...	...	...	91 (10) May	91
Very Early	Bungulla	23 31	24 43	95	91	115 (8) May	...	16 42	21 4	79	91	91 (9) June	88
	Noongar	23 9	24 43	94	92	120 (7) June	...	...	...	...	...	84 (6) June	84
	Geeralyng	...	...	...	...	105 (1) June	...	...	...	...	...	107 (3)	107
	Carrabin	...	...	...	...	131 (3) June	...	19 46	19 34	101	104	90 (2)	90
Premium	Coneback	16 22	28 2	58	55	104 (11) May	...	13 12	19 34	67	71	102 (9) May	102
	S.H.J.	...	...	...	...	120 (11) June	...	...	...	...	...	88 (12) June	88
	Pusa IV.	21 50	28 2	78	79	95 (10) May	...	...	...	...	...	88 (9) May	88
	...	...	...	...	...	101 (10) June	...	...	...	...	...	88 (8) June	88
Planted	Carrabin	...	...	...	...	82 (4) April	...	...	...	...	...	100 (11) May	100
	Coneback	...	...	...	...	91 (3) May	...	...	...	...	...	94 (11) June	94
	S.H.J.	...	...	...	...	97 (8) June	...	12 34	20 22	62	63	...	...
	Pusa IV.	...	...	...	...	63 (3) May	...	...	...	...	...	91 (9) May	91
Germinated	...	...	...	...	...	97 (2) May	...	...	...	...	...	90 (9) June	90
	...	...	...	...	...	88 (8) June	...	12 24	20 22	61	73	97 (1)	97
	...	...	...	...	...	95 (3) May	...	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	...	...	...	...

* Years in brackets, and month of planting.

Farmers' field trials were conducted at Northampton on Messrs. Drage Bros. and K. Williams' properties. The results of these trials which were conducted under conditions of ample winter rainfall are as under. Both properties are located west of Northampton.

The following shows the monthly rainfall registrations of rain at Northampton during 1942:—

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period.							Total.	Nov.	Dec.	Total for Year.	
1942			9	24	11	99	412	383	243	246	137	88	1,509			1,652

	Mr. K. Williams.					Messrs. Drage Bros.		
	Yield per Acre.				Percentage Adjacent Nabawa Control.	1942.		1941.
	Varietal.	Adjacent Nabawa Control.				Yield per Acre.	Percentage Bencubbin Control.	Percentage Bencubbin Control.
		bus. lbs.	bus. lbs.		bus. lbs.			
Bencubbin	...	...	31 47	29 25	108	13 15	100	100
Eureka II.	...	...	33 47	29 25	115	13 1	98	...
Fedweb	...	...	26 19	29 20	90	9 44	73	83
Ford	...	...	...	...	...	11 31	86	97
Nabawa	...	...	Control	...	100	12 14	92	93
Kondut	...	...	31 31	29 20	107	12 5	91	97
Sutton	...	...	...	...	...	9 30	71	90

OATS.

The grain yield of the leading oat varieties when sown on fallow was determined during 1942 at three Research Stations. The planting of these trials on fallow not only reveals the relative grain yielding capacity of the varieties under test, but also gives valuable data on their straw strength.

The need for improving the straw strength and grain holding capacity of oats is widely recognised and the new crossbred Ballidu, because of its superiority in these respects, must be regarded as a suitable alternative to the leading early variety, Mulga. Ballidu was bred on the light soil of the Wongan Hills Research Station by D. R. Bateman. It matures at about the same time as Mulga, against which it has been tested for two years at the Merredin Research Station and for three years at the Wongan Hills Research Station. In all five trials, which were notable for the favourable pre harvest weather, Ballidu gave superior grain yields. At the Salmon Gums Research Station during 1942, a severe storm occurred just as the early varieties were maturing. Because of the relatively minor damage suffered by the Ballidu in this storm, it outyielded Mulga by a much greater margin than is usual.

Satisfactory grain yields have been given by the new late mid-season variety Dale. This variety has a similar history to Ballidu and was bred to meet the demand for a variety which would mature earlier than Algerian and possess stronger straw than Guyra.

The variety Wongan released some years ago is proving very satisfactory and is increasing in popularity particularly in the northern cereal growing districts. It is very early maturing and consequently should be among the later planted varieties unless it is to be grazed during the winter.

Details of the yields are set out in the accompanying table.

OAT VARIETY TRIALS CONDUCTED ON RESEARCH STATIONS, 1942.

Maturity.	Variety.	MERREDIN RESEARCH STATION.				WONGAN HILLS RESEARCH STATION.				SALMON GUMS RESEARCH STATION.			
		1942 Season.		Average for Period.		1942 Season.		Average for Period.		1942 Season.		1942 Season.	
		Varietal Yield per Acre.	Yield per Acre adjacent Guyra Control.	Per-centage of Control.	1941-42 Guyra Control.	To 1938 Per-centage of Mulga Control.	Varietal Yield per Acre.	Yield per Acre adjacent Guyra Control.	Per-centage of Control.	1941-42 Guyra Control.	To 1940 Percentage of Burt's Early Control.	Varietal Yield per Acre.	Yield per Acre adjacent Guyra Control.
Late ...	Algerian ...	...	...	...	...	...	...	...	...	...	...	...	...
	Dale ...	34 0	30 24	111	102 (2)	...	16 10	17 3	95	93 (2)	123 (3)	13 24	15 32
Mid-Season ...	Guyra ...	...	Control	...	...	93 (7)	...	Control	...	...	107 (11)	...	Control
	Burt's Early ...	...	...	...	...	91 (4)	...	...	...	...	Control	...	...
Early	Mulga ...	36 32	28 16	129	115 (2)	Control	16 19	16 21	100	92 (2)	93 (11)	8 18	15 39
	Ballidu ...	41 32	28 16	147	133 (2)	...	19 6	16 21	116	118 (2)	97 (1)	15 30	15 32
Very Early ...	Wongan ...	35 32	30 24	117	110 (2)	73 (2)	14 32	15 32	94	79 (2)	114 (5)	9 2	15 39
	Palestine ...	...	...	...	...	95 (5)	...	...	...	...	110 (4)	...	...
		Planted on 12th May. Germinated on 25th May.				Planted on 17th June. Germinated on 27th June.				Planted on 14th May. Germinated on 20th May.			

Oat Grazing and Recovery Trial—Avondale Research Station, 1942.

I. THOMAS, Superintendent of Wheat Farming, and
A. J. MILLINGTON, Field Technician.

The ability of cereals to give substantial winter and spring grazing and to later mature satisfactory grain yields varies considerably with both the variety grown and the season. An experiment to evaluate five oat varieties for their ability to yield both green grazing and grain was conducted at the Avondale Research Station during 1941 and again, with the addition of Atlas barley, during 1942. The season opened much earlier in 1942 and good weed control was obtained prior to planting on fallow on April 14th. Germination, however, did not occur until after the mid-May rains. Growth was very rapid and by mid-June when the first grazing was made, the plots of all the varieties except Fulghum were about 6.8 in. high. The plots after sampling, were grazed to a uniform sward on 11th June and again on 14th July after the second sampling. The crop was then allowed to mature and the grain harvested.

	First Grazing.*		Second Grazing.*		Grain Yield.		Mean Yields, 1941-42.		
	23-6-41.	11-6-42.	24-7-41.	14-7-42.	1941.	1942.	First Grazing.*	Second Grazing.*	Grain.
	cwt. per acre.	cwt. per acre.	cwt. per acre.	cwt. per acre.	bus. per acre.	bus. per acre.	cwt. per acre.	cwt. per acre.	bus. per acre.
Ballidu	6.1	12.8	7.0	11.1	6.7	32.8	9.5	9.1	19.8
Dale	5.7	12.5	7.5	11.1	5.6	29.9	9.1	9.3	17.8
Fulghum	5.9	10.8	8.2	10.1	9.1	25.7	8.3	9.2	17.4
Wongan	6.5	14.4	6.8	11.7	3.3	21.7	10.5	9.3	12.5
Mulga	5.7	11.5	6.3	10.2	2.2	19.3	8.6	8.2	11.2
Atlas	...	15.0	...	10.5	...	†21.9	...	...	...
Significant Difference (P = .05)	0.42	0.7	0.58	Not Signif.	1.4	3.2	...	...	...

* On a moisture free basis. For dry green fodder weight add 10-15 per cent. per bushel.

† 50 lbs.

The best return in the 1942 trial was given by Ballidu, a new early maturing variety bred by D. R. Bateman at the Wongan Hills Research Station. The yield obtained from Ballidu was about 26 cwt. of air dry green fodder and 32.8 bushels of grain per acre. These yields are greatly superior to those of Mulga. Ballidu is much more leafy than Mulga and not as sensitive to injury by grazing. In addition to its prolific grain yields it is particularly notable for its strong straw and good standing qualities in adverse weather.

The variety Fulghum has a very long leafy growth phase which makes it ideal for grazing in the early spring. In trials such as the above where grazings are made as soon as one of the varieties included is sufficiently advanced, Fulghum, because of its slow initial growth, is at a disadvantage. Nevertheless it gave 20.9 cwt. of dry material and 25.7 bushels of grain per acre. It must be regarded as an oat to provide early spring rather than winter grazing which can be better supplied by the general purpose oats such as Ballidu or six-row barleys such as Atlas. The rather poor recovery of Atlas barley after the first grazing was due in

some measure to its being severely attacked by the fungus, powdery mildew. The very wet winter no doubt favoured this disease which did not attack the oat varieties to an appreciable extent.

In view of the dry weather in late spring, the yield of the late mid-season oat Dale, was very satisfactory. Wongan yielded well at the first grazing and should be valuable for grazing and recovery in drier districts where the shorter growing season would permit of only one grazing.

The highly nutritious nature of the growing cereal crop is widely recognised and its value in the production of fat lambs clearly demonstrated by other experiments at the Avondale Research Station.

Book Review.

"AUSTRALIA'S DYING HEART."

By JOCK H. PICK.

Melbourne University Press 3s.

The author of this small book of 90 pages was brought up in the inland of South Australia as a pastoralist. His book is the result of long experience in the inland of this portion of Australia combined with keen observation and study and its compilation was prompted by the recognition of the urgency of the need for a national policy of active conservation measures.

He briefly reviews the factors associated with soil erosion problems and the occurrence of deserts in various parts of the world, and with this as a background directs his attention to the situation in Australia. While Mr. Pick briefly mentions the ravages of soil erosion in the wetter and more productive agricultural districts, his main attention is focussed on the salt bush—blue bush country of the inland areas receiving an average annual rainfall of less than 10 inches. Here the problem has become acute and is quite distinct from that of any other part of the Commonwealth. His observations apply particularly to portions of South Australia, New South Wales and Queensland and only in principle to Western Australia, concerning which he appears to have had little information.

The author draws attention to soil erosion as the result of the upset of the delicate balance of nature established before the occupation by the white man and gives evidence of the damage inflicted by overstocking and the depredations of vermin such as the rabbit, in bringing about the destruction of the perennial shrub cover. As much as 90 per cent. of the salt bush and blue bush has been destroyed in some parts and the resultant exposure of the soil to the elements has been disastrous.

Of particular interest are the suggestions made by Mr. Pick for alleviation and rehabilitation. He recommends a more stable and wise system of land tenure coupled with appropriate taxation and fiscal policy, the removal of the incentive to overstocking, unremitting efforts to control the rabbit menace and the formation of a Federal Soil Conservation Service, generously staffed and financed, and with wide powers for constructive and educative action.

It is a stimulating and readable book drawing attention to a major national need for future reconstruction work. Perhaps the chief criticism of the book is that its brief mention of the subject fails to give proper perspective to the more serious and more insidious damage being suffered by the more productive agricultural lands of the higher rainfall areas where conservation measures are just as urgently needed.